# An evaluation of the Land and Environment Planning toolkit for advancing soil and nutrient management in hill country and steepland farm systems

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## Abstract

The Land and Environment Planning toolkit recently re-launched (December 2012) by Beef + Lamb NZ is a package developed to assist the sector with resource and business planning. The toolkit has three levels, from an introductory (Level 1) through to more advanced Levels 2 and 3, each providing a step-by-step guide to assess farmers' with on-farm land and environment issues and includes a framework to address the management of these issues. To date the evaluation of the toolkit has been very limited. It has not been critiqued as a tool for advancing sustainable nutrient management. In this study a multi-disciplinary approach was taken using both quantitative and qualitative methods, including a case study and interactive workshops, to determine the utility and value of each of the three levels of the Beef + Lamb NZ Land and Environment Planning Toolkit (LEP) for advancing nutrient management.

The research included a case study (farm interview) and interactive workshops, to determine the utility and efficacy of each of the three levels of the LEP toolkit and whether they progressively add the elements, flexibility and rigour necessary to address the current and future drivers that will shape sustainable nutrient management (SNM) for hill country and steepland farm systems. Primary data was collected during the fieldwork and interviews on the case farm, and during the LEP workshop meetings and immediately following through interviews. Data was analysed separately against each of the three key drivers identified in the literature review (freedom to operate, nutrient use efficiency and ability to demonstrate sustainability) using a framework developed as part of the study. Data collected as part of the analysis of the utility of each level of the toolkit was coded and grouped according to the degree the information obtained assisted in addressing the elements identified in each of the three driver identified for advancing soil nutrient management.

The research findings concluded that the introductory (1a and 1b) levels of the toolkit proved useful as a desktop investigation that allowed the identification of factors influencing environmental issues, but offered little assistance in developing tailored solutions. The research findings recommend that Level 1 is used as an introductory package, with a pathway to Level 2 built into the initial conversation. Levels 2 and 3 proved more useful in advancing nutrient management by assisting with resource mapping and planning, but it was Level 3 that provided the most utility for addressing all the drivers of sustainable nutrient management (i.e. Freedom to operate, nutrient use efficiency and demonstrated sustainability). This was largely through the use of a highly detailed and comprehensive analysis and review of the farm's resources, nutrient budgets, strengths and weakness analysis for the LUC classes identified for the farm and greater level of interaction between the farmer and the land use experts. Although it was highlighted that the Level 3 evaluation might not be comprehensive enough to achieve further growth or deal with the issues at hand, further investigation into the land resources and the linkages between nutrients and the landscape is required. The findings of this research will give an indication of the utility of the toolkit,

and identify, if necessary where modifications can be made to improve utility and reporting, not just for the farmer but also for the Sheep and Beef sector.

The findings from this research also supported the use of the LEP toolkit as a stepwise approach, and find that any programme (LEP Level 1, 2 and 3) needs to be simple enough for the lower end of farmers to buy in and not be intimidated, whilst providing a framework for a natural progression of stages for the farmers to continually improve through the completion for each level of the toolkit, as well as a final level that has sufficient rigour to produce a robust defendable nutrient management tool.

Several recommendations for the future development for the LEP toolkit are made. Investigate the possibility of combining Level 1 (1a and 1b) with Level 2 as a single exercise. Within the same workshop, Level 1 would be used as an introductory step to the completion of the Level 2 farm plan. Greater integration of the Level 3 with other farm planning tools has the potential to extract greater value from the information collected and analysis as part of the process of developing the plan, but also the opportunity to better integrate resource management into the business planning cycle. An integrated farm planning tool would increase the utility of the toolkit by allowing the SNM issues to be considered alongside all the other drivers influencing the business.
The addition of these proposed modifications for the toolkit would not only be of benefit for the farmer undertaking the LEP toolkit evaluation but also for continuing to extend the overall knowledge of the industry and Sheep and Beef sector as we move into a more environmentally aware and agriculturally sustainable future.

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## List of Acronyms

BMP – Best Management Practices
BNF – Biological Nitrogen Fixation
DM – Dry matter (per hectare)
EMS – Environmental Management systems
FARMS – Farmer Applied Resource Management Strategies
FCPNM – Fertiliser Code of Practice for Nutrient Management
FDE – Farm Dairy Effluent
GAP – Good Agricultural Practices
HEL – Highly Erodible Land
HRC – Horizons Regional Council
LEP – Land and Environment Planning tool kit
LMU – Land Management Unit
LUC – Land Use Capability
MAF – Ministry for Agriculture, Forestry and Fisheries
MfE – Ministry for the Environment
MPC – Maximum Permissible Concentration
MPI – Ministry for Primary Industries
NMP – Nutrient Management Plan
NPS – National Policy Statements
NZFLRC – New Zealand Fertiliser and Lime Research Centre
NZFSA – New Zealand Food Safety Association
NZLRI – New Zealand Land and Resource Inventory
OnePlan – Horizons Regional Council one plan document
PCE – Parlimentary Commision for the Environment
POP – Proposed OnePlan
PSWP – Primary Sector Water Partnership
RC – Regional Council
RMA – Resource Management Act (1991)
SLUI – Sustainable land Use Initiative
SNM – Soil and Nutrient Management
SUBS – Sustainable Land use Underpinning Business Success
SWOT – Strengths and Weaknesses, Opportunities and Threats analysis
WFP – Whole Farm Plan
WRC – Waikato Regional Council

# Chapter One Introduction

This chapter introduces the aim of the research and leads on to the objectives of the study and the potential utility of the findings of this research to the Sheep and Beef sector. The chapter also sets out the overall structure of the thesis and briefly describes each chapter.

The question of the biophysical 'sustainability' of the New Zealand hill country and steepland environment is centered around the inherent physical instability of the landscape and the environmental issues that have arisen from land use and intensification resulting in the potential for greater soil erosion and associated sediment and nutrient losses. Environmental issues such as erosion, sediment loss and associated nutrient losses (namely phosphorus and less so nitrogen) and enrichment of waterways are the main off site challenges facing Sheep and Beef operations on these landscapes.

Government and Regional Councils address these issues through a mixture of regulatory and non-regulatory approaches e.g. Regional Plans, rules around vegetation clearance and building tracks Sustainable land use initiatives. The industry (Beef + Lamb NZ, Fertiliser companies etc.) has also released and promoted approaches (Environmental Management Systems, Quality Assurance Programmes, OVERSEER™ nutrient budgets, Best Management Practices packages etc.) that attempt to manage nutrients on Sheep and Beef farms and beyond. There is evidence to suggest there is a considerable amount of confusion over the role each approach plays and the utility of the many tools available to Sheep and Beef farmers with regards to their ability to address the current and emerging nutrient issues. These non-regulatory approaches include a range of soil and environmental programmes offered e.g. Horizons Regional Councils 'Whole Farm Plan' and promotion of the OVERSEER™ nutrient budgets through to Beef + Lamb NZ's Land and Environment Planning toolkit (LEP toolkit). However, there appears to be little connection at times between these approaches.

As Regional Councils and the industry move to use these nutrient management tools (e.g. OVERSEER™ nutrient budgets, nutrient management plans, farm plans etc.) in managing nutrients and as an approach to demonstrate to the community sustainable land use, the integrity and applicability of these tools against the drivers for advancing soil and nutrient management (SNM) must be considered. Just how these tools should be evaluated against the suite of nutrient management issues is still a work in progress.

The aim of this research is to evaluate the utility of the three levels within the Land and Environmental Planning (LEP) toolkit of Sheep & Beef NZ as a nutrient management tool for tackling current and future nutrient issues. The evaluation will include an analysis of the tools ability to identify and address current nutrient management challenges in a future environment where there may be limits on emissions off-farm.

## 1. Research aim and objectives

The aim of this study is to gain insights into the use of SNM tools available to the Sheep and Beef sector of New Zealand hill country and steepland farm systems.
To achieve this aim, four research objectives are tackled.

1) A review of the state of play of the three main drivers shaping current and future SNM on New Zealand Sheep and Beef farm systems:
   i) Freedom to operate in light of current legislative processes
   ii) Nutrient use efficiency based on availability
   iii) Demonstrated sustainability to the community and 'customer'
2) Investigation of the current effectiveness of the suite of nutrient management tools available to New Zealand Sheep and Beef farmers.
3) Evaluation of the ease of use, and applicability of the LEP toolkit for the Sheep and Beef sector, using a case study farm (Springvale Station) and two workshops.
4) Critical critique of the strengths and knowledge gaps of the LEP toolkit in the provision information (Level 1-3) required to inform the nutrient management decision process.

## 2. Significance of research

The purpose of this research is to provide insights into the utility of the LEP toolkit for advancing sustainable nutrient management. These findings will be significant to the Sheep and Beef sector and in particular Beef + Lamb NZ as the LEP toolkit is their flagship environmental management tool for supporting farmers for evaluating, monitoring and reporting back to the customer, through to government on the progress of Sheep and Beef farmers towards meeting their environmental goals. The findings of this research will give an indication of the utility of the toolkit, and identify, if necessary where modifications can be made to improve utility and reporting, not just for the farmer but also for the Sheep and Beef sector.

## 3. Structural overview

This thesis is presented in six chapters. Chapter One introduces the aims and objectives of the research and the significance of this research to the Sheep and Beef sector. Chapter Two provides background to the key drivers for shaping SNM, along with a description of the current suite of nutrient management tools available to New Zealand Sheep and Beef farmers. Chapter Three includes the research design and is described in two parts: first the case study, and second the Workshop interviews. The first section describes the setting for the case study (farm) and outlines the steps taken to evaluate the toolkit against a set of drivers (described in Chapter Two), data collection procedures and qualitative approaches for analysing the research findings. The second section describes the Beef + Lamb Workshops, and describes how the interviews were conducted and observations made. Chapter Four, the research findings for the investigation are presented in two parts mirroring Chapter Three. The first section contains the findings from the case study approach and the results from the qualitative analysis. The second section contains the observations and findings noted during the LEP workshops and the interviews. Chapter Five includes a discussion of the research findings and the key results from the case study farm, and workshop analyses are compared and contrasted with those reviewed in the literature, and the major themes for this research are highlighted. Conclusions are drawn in Chapter Six with some recommendations made for the future direction of the LEP toolkit.

# Chapter Two Literature review

## 1. Background

Agriculture plays a major role in the New Zealand economy with agriculture and related industries accounting for approximately 10% of Gross Domestic Product for 2010 (MAF, 2010) with 80-95% of the agricultural products produced exported overseas (Hedley et al., 2011). The reliance of NZ on agriculturally derived products and the subsequent effect of their production on the environment and its sustainability in the future is therefore of equal importance. As New Zealand agriculture has developed over the last 100 years, a range of environmental problems have arisen contributing to water quality concerns, including sediment loss, soil erosion and nutrient runoff into surface and groundwater in some areas of the country.

Of New Zealand's 27 million hectares, approximately 50% of the total land area (13.9 million hectares) is used for agricultural purposes (MAF, Unkown). Of this a further 70% is described as hill country (slopes 15°-25°) and steepland (>25°), two thirds of which is located in the North Island (Smith et al., 2007). The primary use of this hill country and steepland is Sheep and Beef pastoral farming systems (Ministry for the Environment, 2007). Sheep and Beef farm systems are often based on land which is considered environmentally marginal in its natural state, due to low natural fertility, steep slopes, susceptibility to erosion and subsequent lower pasture cover (Blaschke et al., 1992). Farming practices (including fertiliser application, vegetation change and stock-rate and animal type) if not mindful of the strengths and weaknesses of these landscapes can exacerbate the soil issues already present (e.g. erosion and sediment loss).

The sustainability of New Zealand's biophysical environment is at the best of times unstable and the environmental issues that have arisen from pastoral farming is a result of New Zealand's geological position, (short) agricultural history and climate. The country's position on the boundary between Australian and Pacific plates causes frequent earthquakes, movement along fault lines and a rapid rate of uplift (up to 4mm a year). This combined with the geologically young 'soft rock', weathered sedimentary rocks and intense storm events leads to a susceptibility for erosion and land use issues to occur (Blaschke et al., 1992; DeRose, 1995). This vulnerability was exposed in the Manawatu/Wanganui region during the 2004 February storm with approximately 30 million tonnes of sediment ending up in waterways affecting over 100,000ha hill country and causing over $300 million dollars in damage (Horizons Regional Council, 2007b). From this event the Sustainable Land Use Initiative was formed to protect hill country and lowland areas from future storm events and ongoing costs from the 2004 storm event (Mackay, 2008).

Pastoral agriculture is an integral part of the New Zealand economy and society. Long-term sustainability demands we protect our land and surrounding environment. To do this we need to understand the strengths and weaknesses of our land resources, and how management decisions impact on these resources in the business of farming. Further to this, we need a comprehensive land management plan in place to be able to sustainably farm the landscape and to demonstrate to the government, community, national and international markets that we are sustaining these resources.

Beef + Lamb NZ recognise the necessity for a comprehensive Land and Environment Plan - LEP toolkit for resource management to underpin sustainable land use. The toolkit is used to assess a farm's land and environment issues and using this assessment, a framework to address the management of these issues is developed. The LEP toolkit was chosen as the case study EMS in this study due to its availability to New Zealand hill country and steepland farmers. The toolkit was also chosen because of the advantages it presents the real life situation of a farmer's needs as a cheap, voluntary and essentially easy to use, toolkit. To date the evaluation of the toolkit has been very limited. To the author's knowledge it has not been critiqued specifically for the effectiveness of using the step-wise approach (Level 1, to 2, and to 3) of the toolkit for the identification of (page 45) SNM issues, or for gathering information for decisions around nutrient management.

## 2. Drivers for advancing soil and nutrient management

Environmental sustainability is of increasing importance to the worldwide agricultural sector. This is not just due to the increasing scarcity or increasing costs associated with nutrient resources and the demand of consumers wanting a healthy and sustainably produced product, but also from regional and national authorities that are under increasing pressure to demonstrate on a national and international stage that natural resources are being sustainably managed. In the New Zealand Sheep and Beef industry there are a number of drivers for advancing soil and nutrient management (SNM) practices. These include: international market, cultural, social, regulatory and economic drivers (Parminter et al., 2004; Paterson & Dewes, 2011). For the purpose of this study these main drivers have been bundled into: freedom to operate, nutrient use efficiency and ability to demonstrate sustainability (Figure 2.1).

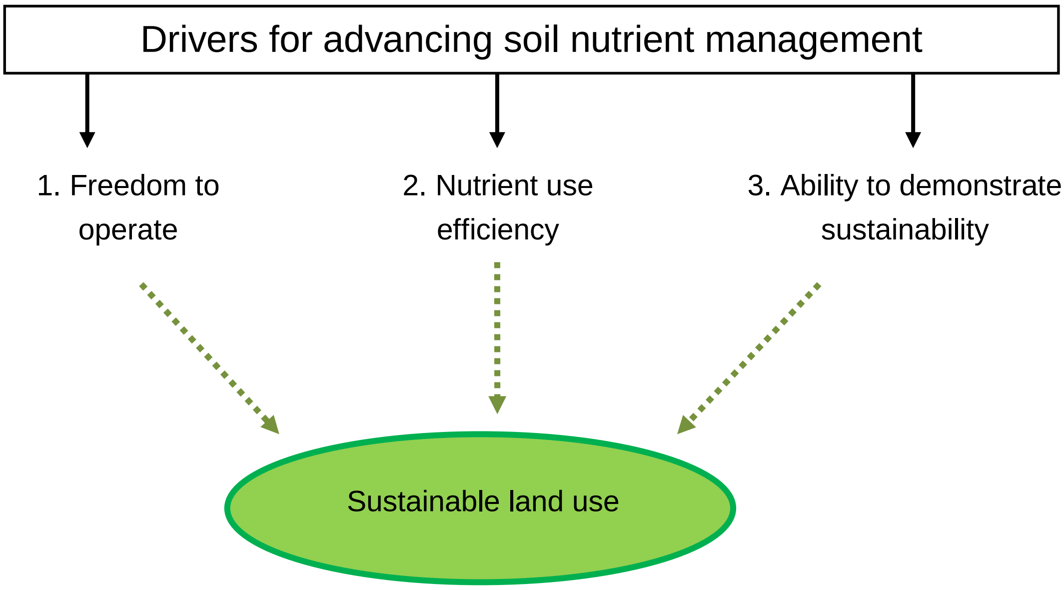


***Figure 2.1*** *The main drivers for advancing soil and nutrient management practices highlighted in this research.*

***Source:*** *Figure adapted from Mattison and Norris (2005).*

### 2.1 Freedom to operate

The intent of this section is to provide information on the current nutrient management practices in New Zealand and reviews the approach adopted by Regional Councils and industry bodies in response to the drivers facing these agencies.

#### 2.1.1 National policy approaches and policy statements

Previous laws have been developed to regulate and control the effects agricultural activities have on the environment including: Soil Conservation and Rivers Control Act 1941, Local Government Act 1974, Crown Minerals Act, Environment Act 1986, Biosecurity Act 1993. The main statute for governing and regulating SNM in New Zealand today is the Resource Management Act (RMA, 1991) (Figure 2.2).

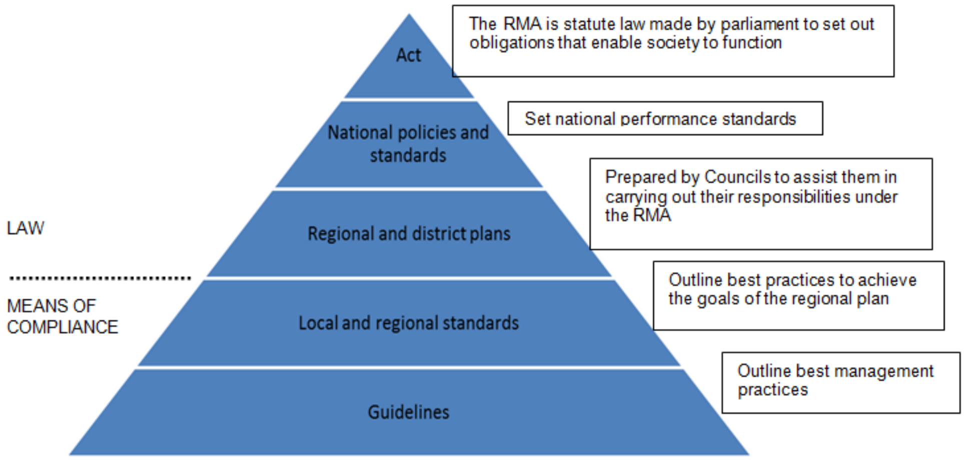


***Figure 2.2*** *Relationship between government and regional authorities in addressing soil and nutrient management responsibilities.*

The RMA is the main piece of legislation in New Zealand that sets out how the natural and physical resources of the environment are managed. The RMA was passed by parliament in 1991 to replace many resource-use based regimes that had been used in the past such as Town and Country Planning Act 1977, Water and Soil Conservation Act 1967, Soil Conservation and Rivers Control Act 1941 and the Minerals Act. A total of 78 statutes and regulations were replaced by the single piece of legislation for the management of water, land, soil and air resources. Instead of an individual approach, the RMA was an integrated approach of the different sectors (land-use, forestry, pollution, traffic, zoning, and water and air quality) that aims to introduce the concept of environmental sustainability into everyday planning. Since its introduction, the RMA has undergone multiple changes to incorporate new research and development of technology, changes in legislation and responses to public perception.

The key idea that has been developed in the RMA is to promote and ensure the sustainable management of the country's natural and physical resources. Sustainable management is defined by the RMA as *"managing the use, development and protection of natural and physical resources in a way, or at a rate which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while-*

a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
b) safeguarding the life-supporting capacity of air, water, soil, and ecosystem; and
c) avoiding, remedying or mitigating any adverse effects of activities on environment ".

Here the RMA states that the government has a responsibility to look after the soil and ensure its use for future generations. However, the current NPS and Regional Councils regulate access to natural and physical resources, but only captures effects based activities within their regulatory framework (e.g. resulting water quality from nutrient discharge). This means that technically it is legal to effectively damage soil resources, as long as there are no specific adverse effects on the environment resulting from the activity. As a result of the amalgamation of laws, the RMA deals less with specific land and nutrient management issues than its predecessors. Instead it more addresses the issues attached to ‘effects based activities’. The sections of the RMA that are relevant to soil and nutrient management are found in sections 9, 10, 14, 15, 17, 30, 69, 70 and 107 of the Act. The main rule that affects soil and nutrient management is fertiliser application found under section 15 of the Act: Discharge of contaminants into the environment. While fertilisers are not considered a hazardous substance and are permitted activity (does not require consent), the RMA instead considers the fertilisers as contaminants defined as-

*“any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat”* that results in the following changes when discharged onto land or into water or air:

a) Changes or is likely to change the physical, chemical, or biological condition of the land or;
b) ii) Changes or is likely to change the physical, chemical, or biological condition of the water or air onto or into which it is discharged.

Farm practices use fertilisers which contain nutrients such as nitrogen, phosphate, potassium, sulphur but which can also contain a whole host of other substances that are regarded as contaminants including but not limited to cadmium and fluoride. Therefore, according to this rule, the discharge of any contaminant (including fertiliser) into/onto land or water, and air is permitted as long as it complies with the Code of Practice for Nutrient Management (NZFMRA, 2007). As a result, each Regional Council adjusts their rules in their plans to govern and protect certain activities based on each community’s individual needs and resources, and public perception of what is important.

Further to this rule, section 17 of the Act (Resource Management Act, 1991) states that every person has the “duty to avoid, remedy or mitigate any adverse effect on the environment” arising from an activity carried out by or on behalf of the person whether or not the activity is carried out in accordance with:

a) Section 10, 10A and 20A
b) A national environmental standard, a regional or district rule, or a resource consent

National Policy Statements (NPS) are overview documents used as tools under the RMA to help Regional Councils to manage their nationally significant resources in a sustainable manner, whereas the Regional Policy Statements (RPS) of a region identifies the resource management issues within a particular region. However, a RPS does not set out detailed methods as to how to sustainably manage a particular resource or for meeting national monitoring requirements. Given the vital importance of soil resources to the New Zealand economy, the government recognises that there is a particular need for clear central government policy to set a national direction in order to achieve the purpose of the RMA (1991). Several policies have thus been developed over the years to give direction to Regional Councils across the country. The NPS that involve soil and land-use include:

- *National Policy Statement for Freshwater Management 2011*
- *Proposed National Policy Statement on Indigenous Biodiversity 2011*
- *New Zealand Coastal Policy Statement 2010.*

The management of the land resource needs to reflect the variation between soil resources and different demands on the resource across regions. This includes managing land-use and activities that may affect the soil so that sustainable growth is achieved with a lower environmental footprint.

**2.1.2 Regional Council policy approaches**

Regional and District Councils prepare resource management documents, plans and policies based on the rules and regulations stipulated in the RMA (1991). The policy approaches of two Regional Councils (Waikato and Horizons) from the North Island, New Zealand were assessed in terms of outlining the discussion on the current framework available to address soil and nutrient management issues. Although the information gathered is not exhaustive, it is seen as representative of the regulatory situation likely to be present in a variety of hill country and steepland farming situations that land owners are faced with not just in the central North Island, but throughout New Zealand. The Regional Councils and relevant Regional Plans investigated include:

Waikato Regional Council (WRC)

- *Waikato Regional Plan (2007)*
- *Regional Coastal Plan (2005)*

Horizons Regional Council (HRC)

- *Land and Water Regional Plan (2003)*
- *Regional Plan for Beds of Rivers and Lakes and Associated activities (2001)*
- *Regional Coastal Plan (2002)*
- *Proposed OnePlan – in progress (2012)*

The Regional Plans for both councils have addressed the regions' issues by the significance of the effects of the activity on the environment. Each activity is identified and put into one of two categories based upon their significance:

a) *Permitted* activities that have minor adverse effect on the environment or; activities that have a more than minor adverse effect on the environment that need to be managed to avoid, remedy, and mitigate the adverse effects. These activities are described as *controlled, restricted/discretionary* and require consent from the Council;

b) Activities that have a major adverse effect on the environment are *prohibited* and will not be granted consent**.**

Rules that permit or enable certain activities to occur do so under the conditions that **"***adverse environmental effects are avoided, remedied or mitigated"*. The Regional Council aims to achieve the desirable environmental outcomes and sustainable resource management as required by the RMA (1991).

The key components of the planning systems reviewed are discussed under four headings: discharges to land, discharges to water, land disturbance and riparian zone management. The assessment of Regional Council policies recognised a number of similarities in the approach of the Regional Council to addressing SNM issues. It is apparent that there is increasing awareness within both regions of the impact these issues, such as nitrate leaching, phosphate runoff, soil erosion and nutrient enrichment of surface water, can have on farm productivity and on the surrounding environment. As a result the assessment of Regional Council policies also identified and highlighted areas of concern where policy and regulation of activities are severely lacking and in particular: Discharges to land, Discharges to water, Land disturbance and Riparian zone management.

**Discharges to land**

Waikato Regional Council (WRC) and Horizons Regional Council (HRC) have both limited the amount of N fertiliser that can be applied to between 150-200 kg N ha/year, and for applications of N > 60 kg N ha/year, split dressing applications are recommended and a nutrient management budget and nutrient management plan (NMP) are required. However, there are no guidelines or set criterion as to what constitutes a NMP in Regional Plans at present. Although in the proposed OnePlan this is a definition of what constitutes a NMP.

For the use of nutrients other than N, such as P, K or S under both Regional Plans there are no rules that limit use. Other elements such as Cd and F contained as contaminants within fertilisers (e.g. phosphate derived fertilisers) are also largely unregulated in all the regions at present. Although Cd has a soil guideline value (SGV) of 1mg Cd /kg soil in agricultural soils which additionally leads to Cd concentration limits on future land uses of affected soils (Schipper et al., 2011b). The discharge of nutrients to any land within closed systems such as dune lakes, water courses in sensitive catchments and wetlands, is a strictly prohibited activity in both regions.

Aerial application of fertiliser (namely N) is a permitted activity as long as it meets the following conditions:

- 50m from any rare habitat, threatened or at risk habitat, or heritage land as identified in Regional or District Plan
- 20m from any waterbody or water source e.g. springs, bores

The rules around fertiliser management rely on farmers following Best Management Practice guidelines (BMPs) set out in The Code of Practice for Fertiliser Use

(NZFMRA, 2007).This is in line with the philosophy that farmers are sufficiently self-motivated to make adjustments to their management practices to reduce nutrient losses (Manderson, 2003). However, there are exceptions to these rules, in particular in catchments that are identified as highly sensitive to nutrient loadings e.g. Rotorua lakes, and Lake Taupo, for which nutrient caps have been applied.

**Discharges to water**

Both Regional Councils require a written notification as to the contaminant concentrations, volume, and the present water quality of the receiving water body a minimum of 10 days before the discharge is released.This involves considerable planning, which is not always possible. Both Regional Councils define sediment as a contaminant when discharged to water and so falls under the same rules for water quality guidelines as defined in Horizons' Land and Water Regional Plan (2003). In this plan discharges are permitted as long as none of the following effects occur in the receiving waters as a result of the discharge (sediment) after reasonable mixing:

- The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or
- any conspicuous change in the colour of the water; or
- any change in horizontal visibility greater than 30%

The WRC has an additional policy (Variation 5 – Grandparenting N losses) for managing N discharges into Lake Taupo from the surrounding catchment. Grandparenting establishes a catchment-wide cap on N leaching by allocating each farm a specific on-farm N discharge allowances in the hopes to reduce the catchment's overall N loss. The council aims to achieve a 20% reduction in N emissions to the lake by 2019. This results in N leaching for farms within the catchment to have the N loss capped at current levels (Waikato Regional Council, 2007). Horizons Regional Council have also imposed N loss limits predominantly on class VI and VII land for farms converting to an intensive land uses (e.g. intensive/irrigated Sheep and Beef, dairy conversion etc.). The N leaching limits are based upon the Land Use Capability (LUC) classes on each farm and have a set of targets for the farmers to reach reducing every five years for the next 20 years (HRC, 2010) (Table 2.1).

***Table 2.1*** *Cumulative N leaching maximum by Land Use Capability (LUC) class*

| LUC class | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|
| **Year 1** | 32 | 29 | 22 | 16 | 13 | 10 | 6 | 2 |
| **Year 5** | 27 | 25 | 21 | 16 | 13 | 10 | 6 | 2 |
| **Year 10** | 26 | 22 | 19 | 14 | 13 | 10 | 6 | 2 |
| **Year 20** | 25 | 21 | 18 | 13 | 12 | 10 | 6 | 2 |

***Source:*** *(Table 13-2 proposed OnePlan) (HRC, 2010).*

**Land disturbance**

For both Regional Councils, the rules around land disturbance activities (earthworks, building tracks, cultivation and vegetation clearance) is the main avenue to manage the risk of erosion and sediment loss. In the Manawatu-Wanganui region, HRC have gone one step further and classified land as highly erodible land (HEL) as defined by Page (2005). This HEL land has a range of restrictions on land use that require consent including:

- More than 100m$^2$ or 100m$^3$ of soil is disturbed; or
- More than 100m$^2$ of vegetation is cleared in a coastal region; or
- More than 1ha of vegetation (woody protective vegetation) is cleared on slopes >20°; or
- Any vegetation that is part of a rare, threatened or at-risk habitat type is cleared; or
- Any cultivation on slopes >25°; or
- Any cultivation within riparian zone is 5-10m from any waterbody and on slopes >15°.

However, there are no rules that specifically restrict the land use that generates sediment loss through stating nutrient or sediment loss limits. In particular, in the proposed OnePlan, there are no restrictions to the amount of sediment lost other than areas defined as high risk areas (HEL). Other councils such as Gisborne District Council (GDC) have gone one step further and stated that sustainable land use on land comprised of LUC Classes VIIe and VIIIe is severely limited. This land is required to be mapped at a more detailed scale due to the increased susceptibility to erosion, sediment generation and soil loss present by land use on these land classes (Gisborne District Council, 2009).

**Riparian zone management**

Similar to Land disturbance there are a lot of rules that govern the activities, but none that restrict the use of the riparian zone through stating nutrient or sediment loss limits. Instead Best Management Practices (BMPs) and industry initiatives are promoted such as DairyNZ's 'Clean Streams Accord' (CSA) which encourages farmers (especially lowland land users) to fence their streams and waterways to keep stock out. In addition to these initiatives, is the increasing pressure from the public over the last few years over certain farm practices that are perceived as not being 'environmentally friendly' and therefore, not appropriate practices e.g. animals in streams and waterways.

There are, however, several rules surrounding disturbance of land within the riparian management zone, although these are generally restricted to cultivation and the building of tracks and road maintenance. The following land uses are permitted as long as they meet the following requirements:

- Land disturbance with an area exposed < 200m$^2$
- Volume of sediment disturbed <50m$^3$ (track and road maintenance only)
- Any cultivation within riparian zone is 5-10m from any waterbody and on slopes <15°

### Regional Council initiatives

Additional approaches towards addressing SNM are achieved largely through the promotion of the benefits of implementing Best Management Practices (BMP). There are a number of council-driven non-regulatory approaches available. Both councils investigated, had initiatives that focused strongly on land use and BMP. These include guidelines and handbooks on the land use, proposed BMP and permitted activities within each region including:

*Waikato Regional Council*

- **Farmer's guide to permitted activities (2007) –** This handbook helps farmers understand the various rules of the Regional Council and contains everything from fertiliser and farm dairy effluent (FDE) application to earthworks and vegetation clearance.
- **Clean streams – A guide to managing waterways on Waikato Farms-** This booklet explains how farming practices can affect the region's waterways and offers practical suggestions about how a farmer can minimise their contribution e.g. monitor fertiliser use, keep stock out of waterways etc. Although this is a good initiative in theory, the voluntary nature of the scheme and the inconsistencies between Regional Councils and even individual farms has caused the CSA to fall short of its goal according to Deans and Hackwell (2008).
- **Trees on farms –** is a booklet that is a guide (using local knowledge and scientific data) to growing trees in the Waikato Region. It encourages going to the 'Trees on Farms' Workshop.

*Horizons Regional Council*

The case study (farm) for this research is situated Northeast of Taihape and so falls under the Horizons Regional Council jurisdiction. The Manawatu/Wanganui regions rules and proposed rules in the upcoming plan (OnePlan) are currently on interim decision in the Environment Court and are being appealed to the High Court by HortNZ and Federated Farmers. To determine both the present and future regulatory environment for the case study farm, a closer look at the potential future Regulatory and Non-regulatory approaches is required.

In 2003, the Horizons Regional Council decided to rebuild its current regional policy statement and six operative Regional Plans. The RC consulted with the public as to which issues were important to the community and should be given priority in a single resource management plan. At the end of the four-year consultation period (2003-2007) four main issues for the region were identified. At the beginning of the process these issues were hill-country and steepland land use, loss of native habitat, water quality degradation and increasing water demand. The Regional Council then endeavoured to create an all-in-one document to replace the regional policy statement (RPS) and six operative Regional Plans to manage the region's resources for the next

10 years. Throughout this process several key groups have formed and initiatives have been developed and implemented.

The Farmer Applied Resource Management strategy (FARM strategy), is a proposed regulatory strategy as part of the OnePlan. The FARM strategy aims to reduce nutrient loss (N and P) from intensive land uses (dairy, cropping and intensive sheep and beef) by working alongside farmers within sensitive catchments. This strategy was employed to offer a regulatory framework to address water quality issues within six environmentally sensitive catchments identified by the Council as priority catchments. These include: Upper Manawatu, the Mangatainoka, Lake Horowhenua and Lower Rangitikei catchments (Mackay, 2008; Roygard, 2009). Each farm in the priority catchments is required to have a nutrient budget, comprehensive soil map, and nutrient management plan. Each farm has a specific N loss target and a date that they must comply with the N loss limit stated in their FARM strategy (Horizons Regional Council, 2007a).

In parallel to this planning process, a significant non-regulatory approach to address soil erosion following the 2004 floods, the Sustainable Land Use Initiative (SLUI) was formed. The SLUI initiative was designed to target highly erodible land (HEL) on-farm within the Manawatu-Wanganui region (Dymond & Shepherd, 2006; Roygard, 2009). At the core of SLUI is Whole Farm Plans (WFP). Whole Farm Plans plans are produced at the request of the individual farmers for farms in priority SLUI areas with the aim of achieving long-term sustainable land use. The WFP consists of a comprehensive land resource inventory of the farm (natural resources and farm infrastructure), identification of environmental issues including soil erosion, analysis of the farm business and the development of a works programme to address erosion issues, with a large focus on soil conservation and sediments loss to waterways. In addition to this, the analysis can also include a nutrient budget. (HRC, 2007; Mackay, 2008)

## 2.2 Nutrient use efficiency

The key concept behind nutrient use efficiency (NUE) in New Zealand Sheep and Beef farm systems is the placement of required nutrients in the right ratios (namely fertiliser) where they are needed most in the landscape and therefore, where they are likely to give the most optimal response and be most effectively used. Historically, fertiliser has been used on hill country soils to alleviate phosphate (P), sulphur (S) deficiencies. There has been much less use of nitrogen (N) (Lambert et al., 2000). Until very recently fertiliser use was focused on optimising production, with little consideration of the environmental implications. While small losses of P and N to surface water bodies has little signficance to the production system and NUE, it has a profound effect on water quality (Ledgard et al., 2009; Monaghan et al., 2007). Futhermore, the application of P fertiliser can result in accumulation, Cadmium (Cd) and Fluoride (F) loading of the soils due to the contaminants association with phosphate rock (Loganathan et al., 2003b; Schipper et al., 2011b). The availability of these nutrients (P, N, K and S) for pasture growth is dependent on processes involved in nutrient cycling such as inputs, transformations and losses, as well as transfers between landscape units. The soil environment combined with grazing animals can have a major impact not only on the NUE and nutrient management of the immediate farm system, but also on the surrounding environment.

**Phosphate**

New Zealand soils are naturally P deficient due to the lack of elemental P in the soils parent materials (Gregg & Smith, 1982). Phosphate is a non-renewable resource (Frossard et al., 2000). Phosphate is introduced into the soil system via three main mechanisms: breakdown of soil minerals, fertiliser application and through recycled excretal returns.

Phosphate is introduced into the soil system from the initial breakdown of primary minerals from the parent rocks during soil formation processes (Syers & Williams, 1977). These minerals, commonly apatite and iron aluminum P (Norrish & Rosser, 1983), are broken down via weathering processes slowly releasing the phosphate into soil solution available for plant uptake (Edwards, 1997). Background P levels depend on the extent of weathering of the parent rock, the lithology and concentration of P-containing minerals within the original parent rock (e.g. average P concentration mudstone (440-650 mg P/Kg$^{-1}$) and sandstone (30-490 mg P/Kg$^{-1}$) (Eden & Parfitt, 1992). However, despite this addition of P naturally through breakdown of minerals, total topsoil P contents only range between 0.02-0.5% of P-containing compounds in temperate soils and of this P more than 90% is normally sorbed and unavailable for plant uptake (Maathuis, 2009). The remaining 10% is only a fraction of the amount pastures (namely clover species) need to grow at an economic farm production level; P fertilisers are applied to meet the deficit. This is achieved initially through capital fertiliser application to raise the P status of the soil followed by maintenance dressings (Morton & Roberts, 2004).

Phosphate fertilisers are applied to the soil to increase the plant available pool of P (soil solution) increasing the P available for plant uptake and hence, pasture growth. The application and management of P has been less intensive in the past on hill country pastures than on lowland farms. Regular P inputs are applied to satisfy the requirements for legume growth and hence, provide a suitable environment for $N_2$ fixation (Williams & Haynes, 1990). As $N_2$ fixation by legumes is a significant N source for the pasture, P is applied annually to meet the legumes growth requirements. The rate at which P fertiliser is applied is dependent on the initial soil test value (Olsen-P), soil type, climate regime and level of production (Morton & Roberts, 2004).

All the P excreted is in the dung and of this P, only a very small portion is present in soluble form available for plant uptake (Pi) (Gillingham, 1978). The rest is present in organic forms that undergo mineralisation before the P can be released and available for plant uptake. Environmental problems on hill country farms associated with dung deposition are centered around concentrated P in dung deposited in areas such as stock camps, ephemeral streams and riparian zones, that are susceptible to surface runoff (Gillingham, 1980a).

Phosphate is different to other nutrients in that P cycling is confined to only the terrestrial part of the cycle (Rowarth, 1987), with the greatest proportion of P found within the soil. Phosphate cycling in hill country farm systems mainly occur through chemical reactions in the soil and the transfer of P between the grazing animal and the soil (Cornforth & Sinclair, 1982) (Figure 2.3).

Phosphate undergoes several key chemical, physical and biological reactions in the soil that both increase and decrease the availability of P and result in the transfers of P between pasture, grazing animals and back to the soil (Figure 2.6). Phosphate is captured and incorporated in the organic P pool by immobilisation processes and released during mineralisation into the soil solution available for plant uptake. Phosphate may also undergo sorption and adsorption processes (P is removed from solution short term) and occlusion (long term removal) (Rowarth, 1987). A soil's ability to fix P is called its P retention and is dependent on the soil's ability to hold negatively charged ions, its anion-sorption capacity (ASC). Soils with high ASC in their topsoil are typically weathered andesitic ash soils that contain a high proportion of clay minerals, amorphous Fe and Mn oxides and in particular, the clay mineral allophane, these soils require a lot of P fertiliser to maintain high available soil P levels (Saunders, 1965). In addition to this, a small but significant fraction of P is lost every year to P sorption in pasture based soils. Available P can be removed from soil solution, precipitate with insoluble Fe-Al oxides (amorphous sesquioxides) and accumulate on the surface of minerals common in highly weathered soils or soils derived from volcanic parent material. Soil types that contain the clay mineral allophane are particularly prone to high levels of phosphate adsorption. Phosphate can also be removed via immobilisation into soil organic matter. All these processes decrease the amount of available P in the soil and temporarily "lock up" P from plant uptake. The P is made available again through chemical and biological processes (Chien et al., 2011), however, the timeline for this process is too long for most farming practices and (capital and maintenance) P fertiliser is applied to maintain the soil P levels.

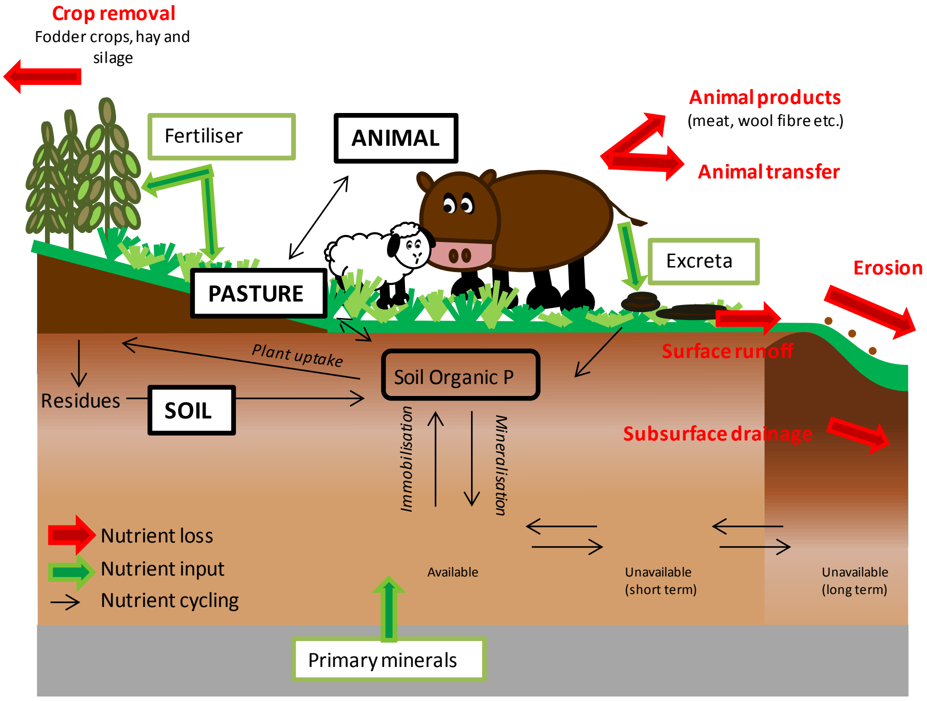


***Figure 2.3** Schematic representation of the P cycle within a legume-based pastoral system*
***Source**: adapted from Di & Cameron (2002).*

Phosphate is cycled through the uptake by pasture via the roots and then subsequent ingestion by the animals when pasture is grazed. In hill country pastures the rate of P uptake is largely influenced by the soil type, slope of the land, and climate. Studies by Gillingham (1980b) indicate that there is a lower rate of pasture P uptake on steeper slopes due to lower solution P and moisture content of the soil which affects the transport of P and ability for plant roots to access the P in solution. The P taken up by pasture can be returned to the soil in either of two ways: after animal ingestion as animal excreta (dung), or as ungrazed plant material (Rowarth, 1987). All P excreted by grazing animals is contained within the dung portion and therefore is preferentially deposited in campsites. According to Gillingham (1980b), in hill country all 0-10° slopes in a paddock will be campsites where up to 90% of the total dung will be deposited. On the other hand P contained within ungrazed plant material will be incorporated into the plant litter which is made up of dead plant material that was initially not accessible, avoided by the stock or has been rejected due to stock trampling and fouling and decomposes in situ where it will be incorporated in to the soil organic-P fraction (Rowarth, 1987; Saggar et al., 1990a).

The most significant loss of P in hill country and steepland farm systems is through erosion. The P lost in soil erosion events can be as P in suspended sediment particles (particulate-P) or as dissolved inorganic P (DIP), dissolved organic P (DOP) and organic P ($P_{org}$) from dung.

Phosphate is different to N in the fact that it is mainly transferred and lost by above ground processes (surface runoff, landslide and sheet erosion), with particulate-P accounting for 60-90% of the total P lost (Parfitt, 2009). Phosphate can also be lost from the system through removal in animal products (refer to Figure 2.4).

Erosion is the loss of soil particles through removal by flowing water, wind or mass movement resulting as one of the main avenues by which particulate-P is removed from hill country soils (Blaschke et al., 2000). Some erosion occurs naturally and is the result of a combination of geological (rock type, weathering, regional plate-tectonics) and climate induced processes (rainfall, frequency storm events) that are essential in shaping the landscape. There are three main categories of erosion that occur in hill country landscapes: surface erosion induced by water, wind or gravity also known as sheet erosion, fluvial induced erosion, such as gully and streambank erosion, and gravity induced such as landslide, and mass movement earthflow erosion. Accelerated erosion, either natural or human induced is undesirable and can be triggered by a number of agricultural activities on hill country farms. These activities include earthworks, building and maintaining roads and tracks, vegetation clearance (shrub or forest cover), cultivation and poor management practices, which can all mobilise significant amounts of soil causing severe erosion and an irreversible loss of a soil resource. The erosion that has the biggest impact on sediment and P loss in hill country and steepland landscapes is sheet and landslide erosion. The following definitions and descriptions are in reference to the LUC handbook (Lynn et al., 2009).

Sheet erosion, also known as sheet wash, is the removal of soil particles via water but through non-channelised overland flow. Sheet erosion is generally the product of when the top soil becomes temporarily saturated and repels any more water, generating overland flow which carries soil solution and surface soil particles in suspension which transports the particles downhill (Gillingham & Gray, 2006). Alternatively it can also occur after drought when the bare soil is susceptible to raindrop impact and dislodges soil particles. In areas where the overland flow is concentrated into channels resulting in a higher velocity, rills can develop. Once the P reaches the water body it becomes part of the dissolved reactive phosphate (DRP) in solution. It is this form of P that poses the greatest risk to water quality (McDowell et al., 2006). In most hill country and steepland systems sheet erosion does not occur over long distances and so may only be responsible for small contributions of P to nearby streams and waterways. However, the movement of particulate P downhill from steeper slopes onto flatter areas (e.g. stock tracks) can result in a significant amount of P loss over time. Areas that are susceptible to sheet erosion include: on bare surfaces such as unsealed roads and tracks, sacrificed paddocks, areas of heavy stock concentration, on steep North facing slopes after drought and on recent landslide erosion scars and debris tails. Prevention and control methods for sheet erosion are to maintain pasture cover and prevent risk of soil compaction (Horizons Regional Council, 2007c).

Shallow landslides, also known as soil slips, are movements of a mass of rock, earth or debris down a slope, under the influence of the gravity. Landslides usually involve a rapid failure along a slip plane at the point of contact between the more permeable material and less permeable material below (e.g. sand and siltstone country). Landslides range in size and volume, however, landslides in pastoral hill country, are typically shallow <1m deep and 150-500 $m^3$ and are influenced by the slope, aspect, vegetation and intense or prolonged rainfall events. Successful control of this type of erosion by planting of poplar poles (*Populus* spp) and willow (*Salix* spp) trees has been well documented (Gray & Sotir, 1996; McIvor et al., 2011).

Hill country pastures demand for P is lower but more varied than lowland farming due to the topography of the land and the resulting focus of land-use on more productive rolling flats, rather than the less productive steep land. The potential for significant P loss through erosion, in particular sheet erosion in summer dry hill country is high during the months February- April (autumn), where the sheet erosion can completely remove the top soil and any dung that it contains leaving areas of concentrated P on the high slope, susceptible to further erosion events. Environmental problems on hill country farms are centered around hot spots of nutrients e.g. stock camp sites and sheet erosion that are susceptible to high rates of sediment and P loss (Gillingham, 1980a).

A significant amount of P is transferred and lost from the soil system through animal products and animal transfer. Loss of P in animal products, such as meat and wool fibre, can be directly related to the concentration of P within the pasture grazed and is what drives the need for replacement P as fertiliser in pastures (Conforth & Sinclair, 1982).

**Nitrogen**

Nitrogen inputs into hill country pastoral systems are sourced from three major sources: Biological N Fixation (BNF) application of nitrogen fertiliser and urine deposition. BNF through legumes and in particular, white clover (*Trifolium repens)*, is the main source of nitrogen in pastures along with subterranean (*Trifolium subterraneum)* and suckling clover *(Trifolium micranthum)*. The clover itself does not fix the N, instead bacteria called Rhizobia found in nodules in the legume's roots fix atmospheric nitrogen ($N_2$) and produce mineral nitrogen that is readily available for uptake by the pasture (McLaren & Cameron, 1996). The inputs of N from clover fixation in hill country pastures varies considerably and can range from <13 kg N $ha^{-1}$ in the unimproved hill country (Grant & Lambert, 1979) to > 100 kg N $ha^{-1}$ on more productive hill country pastures (Ledgard, 2001; Ledgard et al., 1987). The variation in amount of N fixed can be in part attributed to differences in soil P and S fertility down the slope, climate conditions, soil biological conditions, soil acidity, and pasture composition (Hoglund et al., 1979; Ledgard & Steele, 1992). The amount of N fixed in a legume based pasture is a balance of the natural feedback mechanism in the soil between changes in mineral N and accumulation of organic N in the associated pasture grass species (Ledgard, 2001). When mineral N is low, clover thrive and are able to fix $N_2$ readily. However, when the mineral N status of the soil is high (e.g. high rates of fertiliser application), the grass species dominate (organic-N) and out-compete the clover due to the abundance of N readily available for pasture growth (Ledgard, 2001; Schipper et al., 2011a) .

Historically, fertiliser use in the northern hemisphere has relied heavily on applications of nitrogen fertiliser to maintain pasture production. In particular, for the amount of fertiliser applied to agriculturally utilised land, approximately 77.4% is nitrogen based fertilisers with an estimated average application of 59kg N $ha^{-1}$ (Eurostat, 2011). In contrast, in New Zealand pastoral systems, the major N input is via BNF. The BNF inputs are significant and have been relied upon in the past as the main source of N to sustain soil fertility at a level for production (Syers, 1982). However, the N supplied by clover is insufficient to alleviate the N deficiency in the pasture (Ruz-Jerez, 1991). To address this issue, additional inputs of N fertiliser have been added at strategic times to increase the amount of N available for pasture production. Fertiliser N application and management have traditionally been less intensive on hill country pastures than on lowland farms (Table 2.2). Although it is common to apply N fertiliser in advance of a projected feed deficit (Morton & Roberts, 2004).

***Table 2.2*** *Average N fertiliser use according to dominant land use*

| Land description | Dominant land use | N fertiliser use (Kg N $ha^{-1}$) |
|---|---|---|
| **Lowland** | Dairy | 50-200 |
| | Arable | 400- 800 |
| **Hill country and steepland** | Sheep and Beef (extensive) | 0- 50 |
| | Forestry | 0-5 |

***Source****: Cameron et al.,( 2002) and Silva et al.,(1999).*

Nitrogen is recycled in grazed systems in dung and urine from the grazing sheep and cattle (beef). In grazing ruminants, the majority of N is returned to the soil as urine. Previous studies have shown that urine-N makes up between 40-80% of nitrogen in the excretal returns (Steele & Brock, 1985). Dung and urine deposits can contain 130 and 500 kg N $ha^{-1}$ and 1040 and 1000 kg N $ha^{-1}$ for sheep and cattle respectively (Haynes & Williams, 1993; Ledgard, 2001). This value increases as the amount of N content in the animals' diet (e.g. protein) increases. On an average ryegrass/clover pasture, this equates to around 0.8g of N being excreted for every 100g of DM consumed (Whitehead, 1995). Previous studies by Williams and Haynes (1994), have indicated that the N contained in urine is a major contributor to the degradation of surface waters.

In agricultural soils approximately only 1-2% of nitrogen within the soil is in a form available for pasture uptake as either ammonium ($NH_4^+$) or nitrate ($NO_3^-$). The mineral-N is made available to pastures via several pathways: indirectly through nutrient cycling via grazing and excretal N returns and through mineralisation of organic matter such as plant residues (Floate, 1970; Ledgard, 2001) . Animals play a major role in N cycling in grazed pastures (Figure 2.4) and can either increase or decrease the rate of N cycling depending on their grazing behavior and consumption of herbage, degree of treading on soil and pasture, return of N in excreta and removal of N in animal products such as meat and/or wool fibre (Floate, 1981). In Sheep and Beef systems, only a small amount of N (<5%) is removed in animal products, the majority of N ingested by grazing animals is returned to the soil in either urine or dung to a small part of the grazed pasture (During, 1972; Haynes & Williams, 1993).

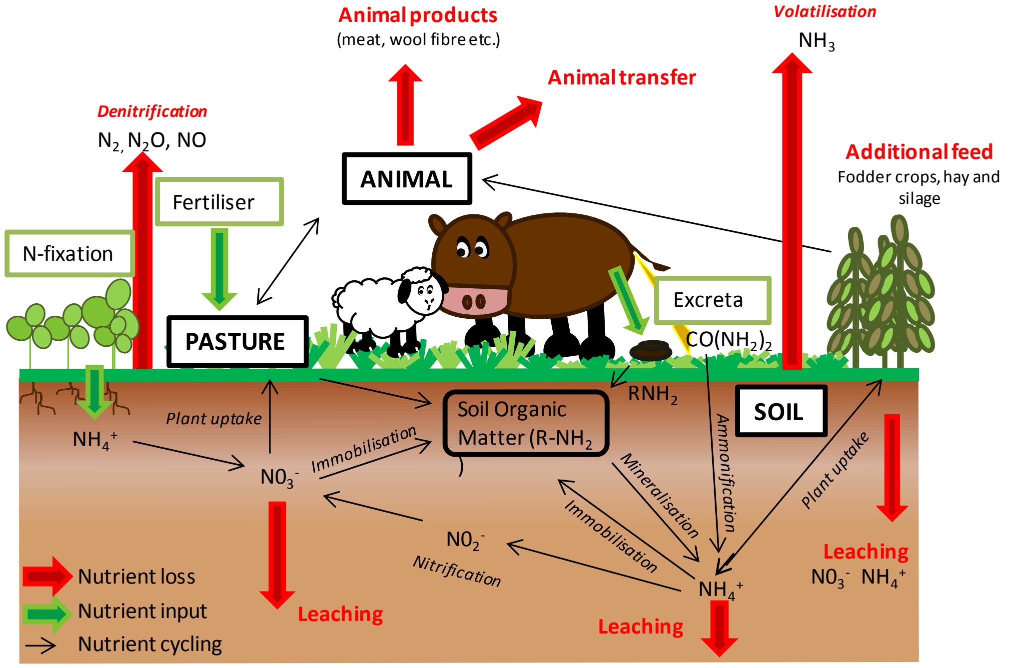


***Figure 2.4*** *Schematic representation of the nitrogen cycle within legume-based pastures.*
***Source****: adapted from Di & Cameron (2002).*

The majority of N in excreta is returned as urine rather than dung (Steele & Brock, 1985). Urine- N termed urea (CO $(NH_2)_2$), is deposited in patches onto the pasture where it is rapidly converted to ammonium ($NH_4^+$) and eventually nitrate ($NO_3^-$). Approximately 15% is lost through ammonia volatilisation (Whitehead, 1995), and a further 1-4% through denitrification, although this loss is likely to be more in wet soils (Parfitt et al., 2008). From the remaining nitrate that isn't taken up and utilised by the pasture, this can be lost through nitrate leaching (N leaching) during drainage events.

Nitrogen in the dung component on the other hand is returned in organic form and is broken down via mineralisation processes. The chemical change of N between being mineralised-N and immobilised-N that is one of the most important transformations N undergoes in the soil (Figure 2.4). Mineralisation involves decomposition and degradation of organic material through microbial or chemical processes that releases mineral N into soil solution. Immobilisation is the opposite of this, with the locking up and transforming of mineral N into organic compounds e.g. utilized by microorganisms (bacteria and fungi) and incorporation into organic compounds (Ledgard, 2001). The initial break down products of the organic-N in the dung/organic matter are ammonium ions ($NH_4^+$) a process carried out by soil microorganisms referred to as ammonification. The subsequent oxidation of this ammonium to nitrite ($NO_2^-$) and then rapidly to nitrate ($NO_3^-$) is referred to as nitrification, and is performed by a range of heterotrophic soil bacteria and some chemoautotrophic bacteria e.g. *nitrosomonas* and *nitro-bacter* which derive their energy from the chemical transformation. The nitrate produced from all of these reactions is either taken up by the pasture or lost to the atmosphere through volatilization, denitrification, and/or lost from the soil profile via N leaching during drainage events.

Nitrogen losses in hill country occur as a result of several processes including crop removal, nitrate leaching, gaseous losses due to microbial processes and through processes such as denitrification and ammonia volatilization. The two main pathways for nitrogen loss that are of importance when considering soil and nutrient management in hill country landscapes are nitrate leaching and nitrous oxide emissions.

Nitrate leaching is the loss of nitrate in drainage waters as it moves rapidly downwards through the soil. Two parameters control the amount of nitrate leached; the concentration of nitrate available and the volume of water in drainage. The drainage waters containing the nitrate filter down through the soil profile and can end up in groundwater. Over time the nitrate can build up and cause environmental issues such nutrient enrichment of ground and local surface waters (Ledgard et al., 2009; Monaghan et al., 2007). Mineral N is found in soils in many forms ($NO_3^-$, $NH_4^+$- weakly exchangeable) that do not adhere onto soil particles and instead are free molecules dissolved in the soil solution. At any one time only a small fraction of the N in the soil is found in available form. The rest of the time the majority of the N is locked up in organic form in plant biomass, humus and/or microorganisms, or attached to clay minerals. Mineral N is released during the decomposition of the organic matter and, along with the soluble N from fertiliser application and urine deposition, accumulates to form concentrated patches of nitrate. It is this nitrate that is leached during drainage events and lost from the soil system (Floate, 1970).

Many areas of New Zealand's hill country and steepland are subject to high rainfall coupled with low evapotranspiration. The rate of evapotranspiration is especially low during the late autumn, winter and early spring. However, even during the summer months there is potential for nitrate to be leached through rapid infiltration through bypass flow via cracks in the soil, root channels and earth worm burrows (Keeney & Gregg, 1982). The amount of nitrate leached in total is dependent on several variables, such as the rate and timing of N fertiliser use, accumulation of nitrate in the soil and intensity of rainfall. Studies by Parfitt et al. (2009) have shown annual leaching values between 20-44 kg N ha/yr for sheep and cattle grazed pastures (similar to dairy leaching values), with the higher values including storm events. Previous studies have shown that the factor that influences the amount of N lost via leaching the most, is stocking rate and the number of urine patches (Ledgard et al., 1999). The type of animal urine also affects the amount of N leached as despite cattle urinating less frequently than sheep, cattle deposit greater volumes than sheep and their urine is more likely to pass the root zone due to this volume. As a result, the distribution of nitrate in urine patches is spread in smaller and more regular concentrated patches for sheep than it is for cattle. Therefore, there is a higher potential for N loss under pastures with a higher cattle to sheep ratio (Williams & Haynes, 1994).

Denitrification is the result of microbial processes that reduce nitrate to gaseous $N_2O$ and $N_2$ more commonly known as nitrous oxide emissions. On hill country and steepland pastures nitrous oxide emissions are estimated to be only between 1-4% of total N loss. This is due to denitrification processes being limited in this landscape to wetlands and the wetter soils where anaerobic conditions occur (Carran et al., 1995; Parfitt et al., 2008).

**Nutrient transfers within the landscape**

In hill country pasture, the topography has a profound effect on the grazing and camping behavior of animals. Animals spend their non-grazing (resting) time on the flat landscape units, rather than the hill slopes resulting in a disproportionate amount of dung and urine being returned in these areas (stock camps) and an uneven redistribution of P and other nutrients (N, K and S) back to the paddock (Gillingham & During, 1973). Sheep create stock camps in small confined areas generally near shelter on the flatter ridges of crests and the basins of paddocks, whereas cattle stock camps are more likely to concentrate at the base of hill units (Rowarth, 1987). These stock camps result in a constant transfer of nutrients in the dung and urine down and/or uphill from the steep country to the campsites on the flatter zones of slopes. This uneven re-distribution of nutrients creates hot spots and is responsible for lowering the overall nutrient status of large areas of the paddock. As a consequence, the single biggest driver of fertiliser P requirements each year is the animal transfer factor (ATF) and the redistribution of nutrients within the paddocks. The 'areas' where nutrients are accumulating (e.g. stock camps, tracks etc.) have the potential to become critical source areas (CSA), and can be susceptible to surface runoff. The CSA have a high density of urine patches (Figure 2.5) leading to high nutrient content that exceeds the pasture's requirements and so losses occur (Haynes & Williams, 1993).

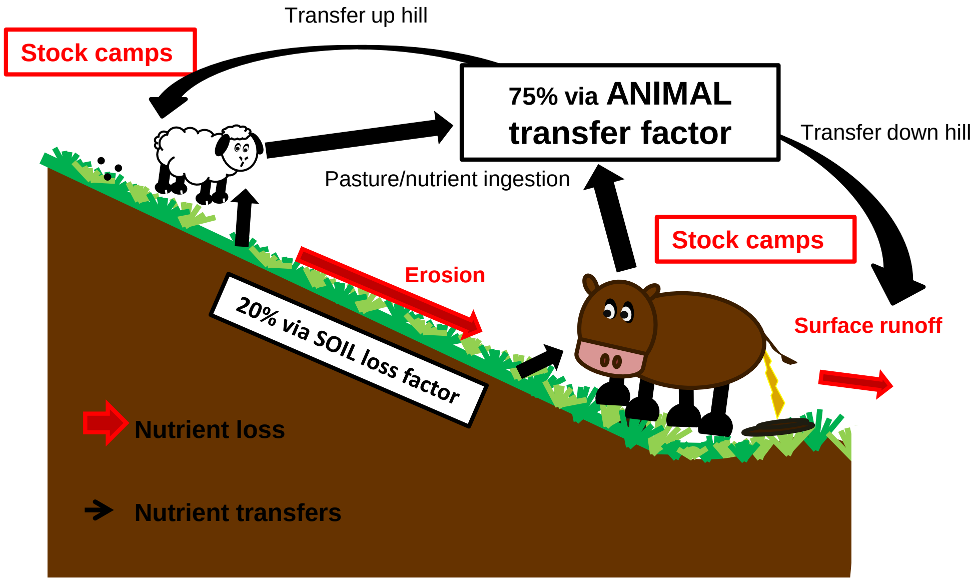


***Figure 2.5*** *Nutrient transfer loss and uneven re-distribution back to the paddock as affected by the topography in hill country and steepland landscapes.*



***Source:*** *adapted from Saggar et al. 1990b.*

According to studies by Saggar (2004) and Sakadevan et al. (1993), up to 60% of the dung and 55% of total urine may be deposited in camp or track sites. This is results in an overall net P and N transfer loss from the steeper slopes where animals graze but do not camp. The uneven redistribution between the amount of organic-N in dung and urine-N deposited driven by grazing animals is one of the primary driving forces behind P and N loss and fertiliser requirements in New Zealand hill country pastures (Ledgard, 2001).

**Impact on the environment**

Over the past 100 years, changes in land-use and management have dramatically altered the landscape of New Zealand. As the farm systems have moved to be more intensive operations, P and N inputs into farm systems have also increased accordingly (Silva et al., 1999). The issues for hill country farmers associated with P losses are tied in more closely with the extent of fertiliser use and the difficulties presented by the different solubilities of P fertiliser. The main issues around N loss on the other hand, are associated with issues stemming from N loss from BNF and efficient placement of fertilisers. It is these areas which remain the main focus of nutrient management research in hill country and steepland farm systems in New Zealand.

Nitrogen and phosphorus inputs from agriculturally derived non-point sources have long been identified as causal agents affecting surface water quality. The addition of these nutrients to the country's lakes, streams and rivers can result in nutrient enrichment of the waters and lead to eutrophication (Ledgard, 2001; McDowell et al., 2009). Symptoms of this include: enhanced growth of phytoplankton and other nuisance aquatic plants, de-oxygenation of the deeper waters when stratification of lake waters occurs (Abell et al., 2011), and a range of adverse impacts on freshwater biota and the surrounding environment (Carpenter et al., 1998). This enrichment consequently has flow on effects into the loss of recreation potential of surface waters, potable water i.e. water the meets the water quality standards set out by ANZECC (2000).

Previous studies have indicated that the potential amount of nutrient lost increases with the intensity of land-use (Abell et al., 2011; Di & Cameron, 2002; McDowell et al., 2009), and a nitrate concentration of 0.04-0.1 ppm has been shown to be enough to stimulate nuisance biological growth, such as periphyton, aquatic weeds and algae, and lead to eutrophication and oxygen depletion of the water (ANZECC, 2000; Biggs, 1985). Nitrogen in aquatic systems is readily available through air-water exchanges with the atmosphere. Typically N is added through atmospheric fixation by blue-green algae and lost via denitrification processes. Phosphate, on the other hand, is sourced from outside inputs such as eroded sediment, surface runoff and direct excretal deposition from animals standing in streams (namely cattle). A minimum P concentration only 0.01 ppm is required to stimulate aquatic weed growth (Sharpley & Rekolainen, 1997). Hence, phosphate is regarded as the limiting nutrient in most aquatic systems (Carpenter et al., 1998; McDowell et al., 2004; Sharpley et al., 1994).

**Potassium and sulphur**

Of less concern than N and P, but still considered important are the nutrients K and S. Historically K and S concentrations in New Zealand soils have been adequate for pasture growth, however, deficiencies have developed in areas with increased intensification of farming practices (Williams, 1988). Inputs for both nutrients in hill country pastoral systems are sourced from three major sources: from the breakdown of soil minerals/organic matter, fertiliser application and recycling urine deposition.

Soils rich in feldspars and intermediate weathering products, such as micas (2:1 clay), have a higher concentration of K than soils of other parent materials. Unavailable K in this form can represent over 90% of the K present in soil. Over time these primary minerals weather to release the K which is then sorbed onto the surface of a cation exchange site of the negative soil particles ( clays and organic matter), where they are exchanged with other cations ($Mg^{2+}$, $Ca^{2+}$) replenishing the supply of exchangeable and solution K  for plant uptake (Williams, 1988). Sulphur, on the other hand, is sourced from the breakdown of sulphide and sulphites in sedimentary parents materials and from the mineralisation of S bonded to organic matter contained within the soil (Metson, 1979).

Typically little K has been applied to hill country and steepland pastures. The amount of fertiliser K required is dependent on the K retention abilities of the different soil groups (low, medium or high). Fertiliser K is applied via top dressing. The most common forms of K fertiliser applied in hill country being K chloride (50% K) and K sulphate (42% K), which are water soluble and dissolve in soil solution to form exchangeable $K^+$ ions (Ravensdown, 2012). In contrast, many pastures receive regular applications of S as a major component in P fertiliser e.g. superphosphate (P and S).

Several factors control K and S fertility in hill country such as nutrient transfer, micro-relief, and erosional processes (Tillman & Officer, 2000). However, the main factors affected in hill country and steepland farm systems are nutrient transfer and nutrient loss. Similar to N, a large portion of K and S is lost through leaching as a result of urine deposition. This is due to the partitioning in the rumen, with over 90% of K and 60% of S deposited as urine of grazing animals (Officer et al., 2006; Sakadevan, 1991). Once again, this urine is distributed unevenly back to the pasture in concentrated urine patches making it difficult for efficient plant uptake. The amount of K excreted is directly related to the concentration of K and S of the herbage ingested. Studies by Campkin (1985) and Hogg (1981) show that typical leaching losses on hill country soils with low K retention, grazed by sheep and cattle  are around 3-4% of total K deposited from dung/urine patches, resulting in the majority accumulating within the soil (Officer et al., 2006). Sulphur on the other hand, is similar to nitrate and is more prone to leaching when applied as a fertiliser and can leach values ranging from 15-33% of the total annual application (Sakadevan, 1991). This leaching percentage increases with grazing pressure and stocking rate. Therefore, both K and S deficiencies can develop in the soils where there is an increase in land use intensification that is not monitored. It is due to high nutrient losses through leaching and accumulation that combined with the increasing cost of fertilisers, drive the demand for more efficient fertiliser techniques.

**On-farm impacts**

Potassium is an essential nutrient for both plant growth and animal production. Generally a K deficiency is not an issue for pasture fed ruminants. However, issues can arise as plants require a higher K content in comparison to animals especially during late winter and spring growing periods where pasture require 3% soil K for optimum plant growth. This is well above the requirements for grazing animals (1%) and the excessive level of potassium can cause animal health issues, such as Hypomagnesemia (Turner, 2012). Hypomagnesemia or grass tetany, and bloat are the only adverse conditions that are related to high K intakes in lactating animals. The condition is caused by depressed plant uptake of sodium (Na) and magnesium (Mg) due to excessive levels of potassium within the soil system (McNaught, 1959). This in turn, reduces the absorption of dietary sodium and magnesium by the grazing animals. Both Na and Mg are naturally deficient in New Zealand soils and integral to animal health and plant growth and hence, can have a major impact on animal as well as pasture production (During, 1972; McNaught, 1959; Smith & Middleton, 1978).

Sulphur is also an essential nutrient for both plant growth and animal production; however, a deficiency in S is more of an issue associated with pasture growth. This is due to S being required to synthesize plant proteins and amino-acids and is particularly important for efficient $N_2$ fixation by legumes. As S is leached easily from most soils, when an S deficiency in hill country soil occurs, a deficiency in N is also likely due to the close relationship between N and S. Therefore, an S deficiency can lower $N_2$ fixation, plant uptake of N and hence, overall pasture production (Sakadevan, 1991).

**Contaminants**

Cadmium (Cd) and fluoride (F) are both contaminants found in P fertilisers. There are several sources for Cd and F in agriculture: fertilisers derived from P rock, atmospheric deposition from volcanoes, forest fires and industrial emissions, and the application of sewage sludge and industrial waste to pastures (Kim, 2005; MAF cadmium working group, 2008). The latter are considered to be more a problem in Europe and North America (Gray et al., 2003). In New Zealand hill country farm systems, the main input for both Cd and F is as trace element impurities found as contaminants in P fertilisers (Sauerbeck, 1992). Phosphate fertilisers are sourced from mining phosphate rock (PR). The mined rock contains Cd and F that is then applied to the soil as part of the fertiliser mix (Loganathan et al., 2003a). The origin and the environment in which the PR formed greatly influences the level of impurities (Cd & F) the rock may contain e.g. PR rocks formed, in a sedimentary environment such as oceanic basins, contain more impurities from the settling debris than sediments that formed in other environments. Phosphate rock formed due to igneous processes have lower Cd content due to cadmium volatilisation at temperatures greater than 765°C, which is well below that of the environment in which the igneous phosphate rock has formed (Loganathan et al., 2003a). Up until the early 1990's, New Zealand (and Australia) sourced their PR from the Pacific, Nauru and Christmas Island. However, this has now changed since these sources of PR were discovered to have a particularly high Cd content, with P fertilisers sourced from this material containing Cd concentrations ranging between 34-69µg Cd $g^{-1}$ fertiliser (Rothbaum et al., 1986).

A portion of the F component in the parent PR is also through volatilisation during the acidulation process (Loganathan et al., 2003a). The remaining F content in the fertiliser is lowered further by the addition of sulphates (single super phosphate fertiliser - SSP) and ammonium (ammoniated sulphates) resulting in a concentration of F in P fertilisers between 1.3 - 3.0% (Mclaughlin et al., 1996). The total F content in soil varies widely depending on a range of factors including F content of the parent material and fertiliser application. In New Zealand grazed pastures, the concentration of F in soil ranges between 39-470 mg F/kg of soil and at present, F levels in agricultural soils do not pose any immediate risk to the environment but can pose a problem for animal health (Loganathan et al., 2003a; Mclaughlin et al., 1996).

In the North Island New Zealand hill country and steepland, both Cd and F are added to the soil through fresh deposits of ash from volcanic eruptions. The concentration of F in volcanic ash can be anywhere between 300-900 ppm. This can result in a large amount of F added to the soil during a single volcanic event (Cronin et al., 2000). Therefore, soils from volcanic origin or receiving regular volcanic inputs such as those in the central North Island, the greater Taranaki region and the alluvial river plains draining from these areas are likely to have soil with a high total F content (Molloy, 1998).

The cycling of Cd and F within hill country soils is limited largely to the accumulation of these contaminants within the soils, pastures and the grazing animals. There are several soil factors that influence the accumulation of Cd and F within the soil: pH, organic matter content, concentration of silicate clay and Fe and Mn oxides, and mobility down the soil profile. The pH of the soil is the most significant factor controlling the availability of both Cd and F as it influences the concentration of soluble ions ($Cd^{2+}$ and $F^-$) in soil solution. At pH values lower than 5, the concentration of Cd increases as the heavy metal becomes more mobile. However, in soils with pH values above 6, the concentration of $Cd^{2+}$ in solution is decreased due to the increased rate of adsorption onto organic matter and clay minerals within the soil and in extremely basic conditions cadmium-carbonate complexes ($CdCO_3$) can be precipitated (Loganathan et al., 2003a). In comparison, F behaviour in soil is more similar to that of P, with sorption at its greatest between pH 5.5-6.5. The formation of Al-F species as the pH lowers, occurs in more acidic environments, whereas in more basic environments $CaF_2$ can be precipitated out of solution (Barrow & Ellis, 1986).

The organic matter content and concentration of silicate clay minerals and amorphous iron, and manganese (Fe and Mn) oxides influence the availability of both Cd and F in the soil. High organic matter content in particular, forms very strong bonds with Cd. The Cd itself forms very strong bonds with the element sulphur, which is present in organic matter compounds and fixes the Cd, resulting in it being less mobile and available for plant uptake. Conversely, when organic matter is removed via oxidation processes, the bonds are broken and the Cd becomes more mobile and phytoavailable for plant uptake (Kim, 2005; MAF cadmium working group, 2008). Fluoride on the other hand, despite its very strong sorption to soil particles, has a very low affinity for organic matter and so is not governed by the organic matter content (Cronin et al., 2000). Both Cd and F form strong bonds with silicate clay minerals and amorphous Fe and Mn oxides and in particular, the clay mineral allophane, most commonly found in highly weathered volcanic soils. Consequently, as the clay and Fe/Mn oxide content of the soil increases, so does the adsorption of Cd and F within the soil (Kim, 2005; Omueti & Jones, 1977).

The mobility of Cd within pastoral soils is very low and hence, the potential for Cd to accumulate in the topsoil is very high. This accumulation is further amplified by the low uptake of Cd by plants, low potential to be lost in erosion, and very low leaching losses due to its low solubility (Loganathan & Hedley, 1997). Fluoride behaves in a similar manner to Cd as it also accumulates within the soil and is not easily lost through leaching (Mclaughlin et al., 1996). In contrast to the nutrients N, P and K, there is minimal loss of Cd and F from the soil system. Instead there is more of a problem with the accumulation of these contaminants within the soil profile and subsequent risk they pose to animal health, public perception and the associated problems with future land uses of soils with high levels of heavy metals and contaminants (Loganathan et al., 2003a).

**On-farm and off-farm impacts**

Cadmium levels in agricultural soil has been recognised as a world-wide developing issue, given its behaviour in soil and phytoavailability and its potential to enter the food chain through crops or the livers and kidneys of grazing animals (Mclaughlin et al., 1996). This is due to Cd being a toxic heavy metal that bio-accumulates within the body's excretory organs causing liver damage and in extreme cases death. Therefore, the concentration of Cd within the kidneys and excretory organs of grazing animals increases with time. This poses a problem not only for animal health but also to the risk of exported meat not meeting compliance levels with food standards overseas (MAF cadmium working group, 2008). Current regulations surrounding Cd in food products have been in place since the 1980-1990's when extreme levels of Cd were detected in exported offal products (Loganathan et al., 2003a). During this period it was estimated that 1/5 of sheep tested had a Cd level above the maximum permissible concentration (MPC) of 1mg/kg fresh weight in kidneys, with the greatest concentrations detected in older animals. As a result, the New Zealand Food Safety Association (NZFSA) established that animal offal products (kidneys, liver etc.) over the age of 30 months (2.5years) were excluded from being exported for human consumption (Kim, 2005). In addition to NZFSA rules, in 1994 New Zealand fertiliser companies voluntarily agreed to start reducing the amount of Cd they sold in their fertiliser. This reduction was achieved by blending high Cd containing PR (Nauru and Ocean Island from guano) with sources of PR with lower Cd content (Kola). By 2002, Cd content within P fertilisers was below 280 mg Cd/kg of phosphate or 26 mg Cd/kg superphosphate which was the maximum value during 1980's. Today, the average concentration of Cd in a phosphate fertiliser mix is about 180 mg Cd kg P (MAF cadmium working group, 2008).

High F accumulation within the soil can lead to increased F uptake in both plants and animals through soil ingestion (Cronin et al., 2000). Despite the benefits of F being instrumental in the development of healthy bones and teeth (Loganathan et al., 2003a), no known environment is F limiting and it is rarely deficient in grazing animals. The problems associated with excess F intake are centered on winter grazing when high concentrations of F are ingested through soil ingestion (Clark et al., 1976). As the total F intake through pasture consumption is very low (<10ppm), F intake by grazing animals occurs through direct ingestion of soil, P fertiliser or volcanic ash (Loganathan et al., 2003a). However, sheep are at a greater risk to F toxicity as they graze lower to the ground and can ingest an average of 110g of soil per day which is 10% average total DM intake (Cronin et al., 2000; McGrath et al., 1982). The extent of F toxicity depends on the concentration of the F ingested at one time. Acute fluorosis is the short term (1-2 days) response to the ingestion of >300 mg F/kg diet and results in kidney failure and death in stock. This is typically the result of stock grazing pasture that has recently had P fertiliser applied or volcanic ash deposited. Chronic fluorosis is the long term reaction to the ingestion of ≤ 60 mg F/kg and 50-70 mg F/kg body weight for sheep and cattle respectively (Clark & Stewart, 1983; Cronin et al., 2000). These regular ingestions within the diet build up over time (months to years) and result in tooth and bone deformities (Clark et al., 1976; O'Hara et al., 1982).

## 2.3 Demonstrated sustainability

The concept of sustainable development (sustainability) has been around for centuries but gained popularity throughout the 1980's during the 'environmental movement.' The concept was formally introduced in the report of the World Commission on Environment and Development (1987), where sustainable development was defined as "*development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs*". During this time, the impact humans and their population growth and use of resources has had on the environment was recognised (Kidd, 1992). Today the concept has evolved to recognise that three key factors: social, economic and environmental, which are interlinked, must be included when discussing sustainable development (Figure 2.6) (Loranzo, 2008).

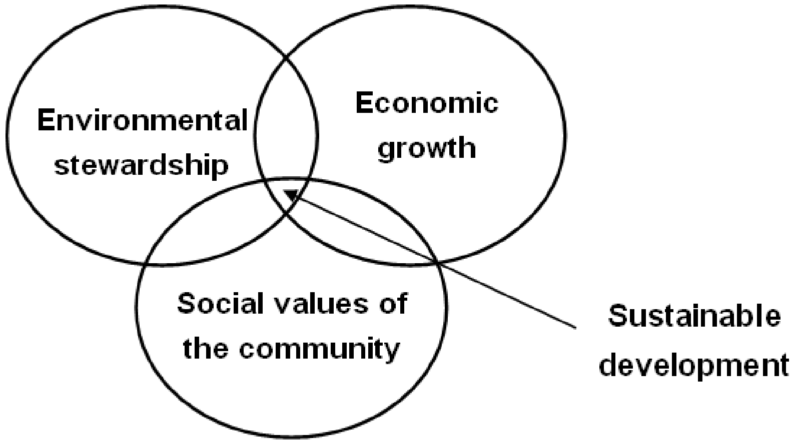


***Figure 2.6*** *Relationship between Social, Economic and Environmental perspectives and sustainable development as the ultimate goal.*

***Source****: adapted from Loranzo (2008)*

Sustainability is an extremely diverse and complex concept and there are numerous definitions for sustainable development. The phrase "sustainable development", however, is a very ambiguous term and has proved very difficult to supply a practical definition, and can mean very different things to different groups of people depending on their goals and interpretation (Blaschke et al., 1992; Manderson, 2003). The concepts and practices that define sustainable farming to the average farmer are reviewed by Parminter (2011). A series of ideas were linked to soil and nutrient management: efficient farm animals, productive vegetation, clean water and unrestricted market access were some of the main factors identified. The drivers for sustainable development are largely due to growing concern over food health, safety, and production, and farm sustainability focused at the farm scale and including the farm's biophysical, social system and 'impacts' on the wider environment.

The trend is towards increased market and public control (supermarkets especially) over land-based production systems in an effort to keep food affordable. As a consequence, food sustainability is a concept which now drives the development of sustainable agricultural systems, underpinning government policies, strategies, legislation and agreements (Manderson, 2003). In addition to the regulatory approach there has also been an increase in the demand for non-regulatory means of ensuring a product's sustainability, termed 'market controlled' approaches. These approaches are responsible for the many Quality Assurance Programmes (QAPs) and Environmental Management Systems (EMS) that are seen in the markets today as a consequence of concerns (drivers) by the consumer e.g. National Animal Identification and Tracing (NAIT). The term EMS refers to any systematic approach to managing environmental impacts of farming, while QAP's refer to any QAP programme that has an environmental component.

**International markets as a driver**

The environmental friendliness of livestock production systems is becoming increasingly important to today's consumers. According to Hoogland and others (2007), however, there are several other key pieces of information that drive the demand for market controlled schemes. These include:

<u>Food health and safety:</u> *The food is produced by a healthy and well cared for animal, and the food (meat, milk etc.) was processed and handled correctly and through the appropriate channels ensuring that it is safe to eat.*

<u>Food sustainability</u>*: Food was produced in an environmentally sustainable system.*

<u>Food identification and traceability</u>*: Provides more assurance for what the food product has been through, where it has come from (country produced) and how far it has travelled (food miles), and what tests and procedures it has been put through and hence be able to more correctly determine the shelf-life of the product.*

There is a developing environmentally-conscious market for high end consumers (mainly the UK and Western Europe) who want a product that is not only of good quality and produced in a safe and healthy environment (food health and safety), but also a product that was produced in an environmentally sustainable manner (food sustainability). As a result of this demand several leading supermarket chains overseas (e.g. UK -Waitrose and Tesco) have introduced QAPs to ensure the quality of the product they import and sell (Rosin et al., 2007). One such scheme is GLOBALGAP, an internationally recognised set of farm standards that are committed to the use of Good Agricultural Practices (GAP) on farms. For farmers to obtain a GLOBALGAP certificate they must demonstrate and show evidence of monitoring that their "food reaches accepted levels of safety and quality, and has been produced sustainably, respecting the health, safety and welfare of workers, the environment, and in consideration of animal welfare issues" (Bureau Veritas Group, 2013). Such audits are viewed as tools by the retail sector and respective industry leaders as providing assurance not only to themselves as the retailer but also to their products' consumers. Without this reassurance, farmers and their produce may be denied access to markets (Rosin et al., 2007).

Environmental labels and the ability to tell the consumer where a product has come from (traceability) have become increasingly important self-regulating forces in the global market. The presence of 'Ecolabels' or 'Green Stickers'' signals to consumers where the product was produced and a lifecycle assessment of the product from 'pasture to plate'. The recent discovery (January, 2013) of horse meat in a range of European-made beef products will only fuel the demand for labelling and official certification of consumable (meat) products.

The environmental friendliness of a product is not the only market driver. Other drivers for EMS include (Northern Ireland Environmental Agency (NIEA), 2009):

- Legal compliance
- Improved environmental performance
- Cost savings
- Customer / client pressure
- Supply chain management
- Enhanced public relations
- Environmental Risk Management

It is this increasing demand for sustainably produced agricultural products (namely meat) that is one of the main drivers behind these market based approaches (Table 2.3) and the demand for the development of more efficient and sustainable farm practices (MAF, 2009).

***Table 2.3*** *Various market based approaches present in the Sheep and Beef sector of today's markets.*

| Type of market based schemes | Description |
|---|---|
| **EUREPGAP** | Assurance that food reaches accepted levels of safety and quality, and has been produced sustainably, respecting the health, safety and welfare of workers, the environment, and in consideration of animal welfare issues<br>-Expect common industry standards across countries<br>-Global standard |
| **Ecolabels** | Are voluntary certification programmes that provide verified links of a products life cycle but various ecolabels can cover anything from animal welfare to Carbon neutral practices<br>-Vary in terms of recognition and credibility |
| **Country of origin labelling** | Verified links from "pasture to the plate" |
| **ISO 14001 – Environment Management System** | Requires a "do, plan, check, review" cycle of actions that are against stated targets<br>-Advocates continual improvement |

The incentive of these initiatives for food producers to manage their environment positively comes directly through securing the market benefits. According to Buller and Morris (2004), two market benefits stand out for producers, in this case Sheep and Beef farmers:

1) Ability to provide credible evidence of environmental performance and hence, gain relatively secure access to an increasingly competitive and regulated market and;
2) The receipt of higher prices through value addition by complying with the standards within.

There are a lot of market based schemes available and most schemes are backed by the respective government regulations and/or have a third party audit and certification process which ensures the quality and reliability of the scheme as well as the product. However, the actual requirements and supposed benefits of some of the market schemes (many Ecolabels) are often loosely defined and open to interpretation. The resulting product is therefore seen as less reliable. Therefore, there is a need for an internationally recognised and accredited market based scheme to ensure a product with a 'proven' environmentally sustainable record (Harris, 2007).

The most common international standard recognised in over 170 countries, is the ISO 41001 standard developed in 1996, which is an evaluation and monitoring framework (Seymour & Ridley, 2005). Many EMS both here and overseas are based upon the protocol set out below and have these underlying principles that are internationally recognised. The organisational structure that includes: "planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining environmental policy" (Northern Ireland Environmental Agency (NIEA), 2009). This list has been shortened down to a simple "Plan, Do, Check and Act" set of requirements.

Key factors according to Carruthers (2011) that are fundamental to an EMS include:

- Voluntary nature
- Ongoing
- Monitoring and recording procedures
- Able to be self-managed by the farmer
- Provides a structure and framework that link a specific policy with environmental performance
- Advocates the concept of continuous improvement

In addition to the key factors above, fundamental steps of an EMS scheme include the ability to:

- Identify any risks
- Set performance targets
- List proposed actions and a timeline of when the actions are to be carried out
- Check off and verify implementation of actions
- Review
- Third party audit
- Option to obtain a certificate when compliant

**New Zealand situation**

Since the 1980's New Zealand farmers have faced a range of market pressures to change their practices with the adoption of integrated management protocols largely driven by market pressures for improved environmental outcomes (Campbell et al., 2006). The primary sector through the Primary Growth Partnership (PGP) has recognised the need to lift its performance (both in production and profit), while at the same time reducing their environmental footprint and ensuring sustainability of the whole system (Falconer, 2011). Previous work within New Zealand (Fairweather & Hunt, 2011; Paterson & Dewes, 2011) and overseas (Beedell & Rehman, 1999; Carruthers, 2011; Cary & Roberts, 2011), have attempted to investigate how the introduction of voluntary schemes have affected land management with regard to both positive (e.g. improved production) and negative effects on the farm environment (e.g. soil erosion, nutrient loss, vegetation clearance). Through these studies it was found that New Zealand meat producers have a competitive advantage over overseas producers through New Zealand's unique pastoral systems (ryegrass/clover pastures) and perceived better on-farm environmental performance than other countries. However, there is concern raised both here and overseas regarding food health, safety, traceability and sustainability of farming practices that has increased pressure on New Zealand meat farmers to adhere to standards set by international markets (Meadows, 2012). Recent government reports have called for more integration within the industry and the movement towards sustainable nutrient management (Growing for Good – PCE (2004), Fresh start for Freshwater report – LWF (2012). These reports have encouraged the use of audited self-managed schemes such as QAP, EMS and WFP, which has seen the release of several market-based agri-environmental programmes. Consequently, the demand for EMS that have greater links between industry bodies, Regional Council authorities and sustainable farming practices, is also set to increase in the future (Manderson, 2003).

In addition to the market drivers there is also a need for the primary industry sectors to demonstrate that they and the farm systems they support, are operating in an environmentally sustainable manner. In response, the primary industries developed a series of industry codes of practice to ensure the sustainability of their products. These codes are the result of not only the international market requirements but also from public perception of the sector and its effect on the environment. There are several industry codes of practice that affect the Sheep and Beef sector. The codes of practice largely encourage farmers to follow a set of guidelines and targets to reduce the impact of their sector's farm practices on the environment (Table 2.4).

***Table 2.4*** *Description of the Industry codes of Practice of the New Zealand Sheep and Beef sector.*

| Industry codes of practice | Description | Sector/ ownership |
|---|---|---|
| **The code of practice for nutrient management** | Focuses on the use of fertiliser within nutrient management planning, occurring in wide range of land-uses.<br>-Following best management practices<br>-Nitrogen fertiliser use<br>-Use of OVERSEER™ nutrient budgets as a nutrient management tool | Fert Research |
| **Clean Streams Accord** | Promotes sustainable farming practices (primarily dairy) and performance targets for the Fonterra suppliers to meet<br>-Excluding stock from streams, rivers and lakes, wetlands<br>-fencing off areas of concern<br>-Regular crossing points, bridges and culverts installed<br>- Systems in place to manage and monitor nutrient inputs and outputs | Fonterra, Ministry for the Environment, Ministry of Agriculture and Forestry and Regional Councils |
| **Spreadmark: Code of Practice for the Placement of Fertiliser in NZ** | A code of practice that ensures farmers and land managers get the best value for money from their fertiliser investment through their fertiliser placement quality assurance programme<br>-Two sections covered: ground spreading and aerial application<br>-promotes sustainable practices through the placement of fertiliser where it is most agriculturally beneficial and poses the least harm to the environment | Fertiliser Quality Council |

Over the years, many schemes developed by the industry have attempted to demonstrate sustainability and this has seen some improvement within land management of the Sheep and Beef sector. By and large, however, the schemes have not addressed major issues within SNM. This is largely due to the argument that nutrient management is not so integral to extensive Sheep and Beef farm systems and so, the cost for farmers to implement these EMS and nutrient management schemes is low on the priority list, although more farmers are becoming aware that soil erosion and sediment loss can be detrimental to the farm business as well as the environment. Hence, demonstrating sustainability as a driver by itself will never be enough for Industry to improve their practices alone if it significantly compromises economic growth.

## 3. Current tools available to the Sheep and Beef sector

Soil and nutrient management is achieved largely through the promotion of the benefits of implementing Best Management Practices (BMP's) to improve farm productivity and minimise the effect farming practices have on the surrounding environment. Soil and nutrient management tools are generally initiated by industry driven motives (Industry codes of practice etc.). Some motives include promoting the sector/company to the wider public and improving public relations and the industry's image. As a result of increasing public pressure to demonstrate the primary sectors sustainability, many agricultural industry stakeholders have released their own version of BMP's, guidelines, self-help booklets and initiatives to help maintain and improve the productivity of their sector (Figure 2.7). Some Regional Councils, forums and industry groups have developed their own initiatives to help promote non-regulatory approaches to managing the effects of certain activities on the environment.

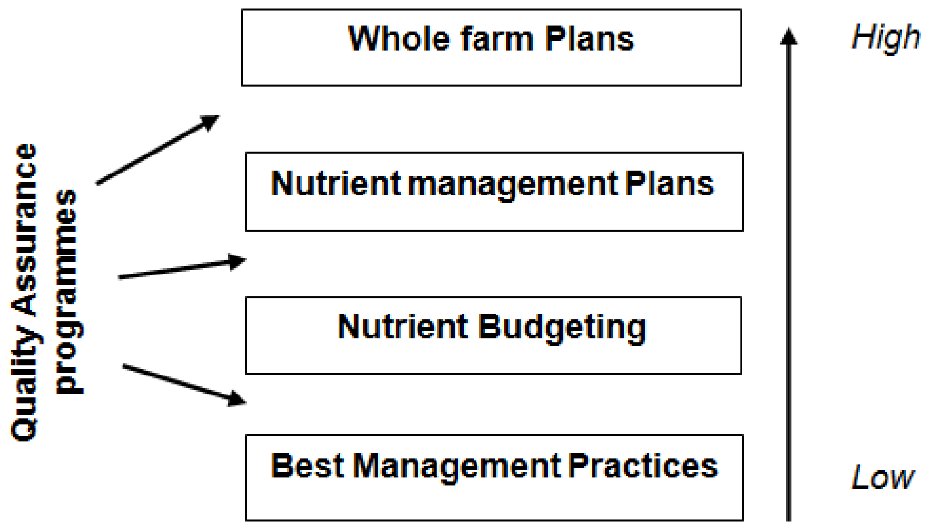


***Figure 2.7*** *The general trend of increasing knowledge and complexity of soil and nutrient management tools available to the New Zealand Sheep and Beef sector.*

Best management practices, otherwise known as good agricultural practices (GAP), is a term used for activities or farming practices that have been proven to achieve the maximum benefit for the nutrient applied while reducing the risk of environmental effects. The BMP attempts to merge the most up to date scientific research with the experience of the land user to suit their local conditions. Although the BMP's are based upon practical research, care must be taken when applying the generic recommendations to specific situations (NZFMRA, 2007). These BMPs are voluntary but are often endorsed by Regional Councils and Industry sectors with initiatives and programmes largely based upon following BMP incentives e.g. Dairy NZ's Clean streams accord (CSA) and Fertiliser Code of Practice for Nutrient Management (FCPNM).

Nutrient Budgets (NB) are a valuable farm-specific tool that provide an overall estimate of the farm's nutrient status for a range of nutrient inputs and outputs (N, P, K, S, Mg, Ca, and Na), and examines the flow of these nutrients within a farm system. Nutrient budgeting software, such as OVERSEER™, is useful in its ability to predict the impact leaching, surface runoff and greenhouse gas losses will have on the surrounding environment (surface water) through calculating the nutrient concentration (kg/ha/year) that is leaving the farm (Morton & Roberts, 2004). These model calculations are based upon a series of user defined inputs (site, soil and production parameters) for each farm block (management) that determine the fate of nutrients on an annual basis sourced from research relevant to New Zealand farm systems. OVERSEER™ is not only used for NB purposes but can also be used to test out different farm management scenarios to increase the efficiency of resource use and decrease environmental impacts (Wheeler et al., 2007). OVERSEER™ is the nutrient budgeting tool of choice by the industry and Regional Councils. The three key assumptions the OVERSEER™ model uses to ensure that the estimates are as accurate as possible are that the input data is: the data inputs are based upon a long term annual average for the farm, practical and reliable, and the system is near equilibrium and is undergoing no major changes (e.g. dairy conversion).

Nutrient Management Plans (NMP) combine all the tools that science has produced to allow a nutrient advisor (fertiliser representative, consultant) to develop fertiliser recommendations which maximise the productivity of an individual farm, while minimising or mitigating the environmental impacts of nutrient loss (N and P) to surface and ground water. Nutrient management plans gather a range of information including: the physical details, the goals of the land managers and any specific regulatory conditions that need to be adhered to by the land managers. Soil, plant and animal tissue testing are also used in addition to nutrient budgeting and cycling models such as nutrient budgeting software- OVERSEER™ (Morton & Roberts, 2004).

Whole Farm Plans (WFP) are an inventory of the core resources found on a farm such as soils, vegetation, and land and water resources. The plan identifies the farm's current level of environmental risk from a number of indicators (erosion, water quality etc.) as well as pasture yield gaps and opportunities for future development along with suggestions of ways to improve the sustainability of the farm. In addition to this, the farms personal and business goals are evaluated along with the strengths and weaknesses of the farm and are combined with the long-term business and resource management plans to outline what needs to be done to achieve new goals. A NMP is a subset of the WFP (HRC, 2010).

On-farm Quality Assurance Programmes (QAPs) refers to a systematic certification for agricultural products. There are many different types of QAPs that vary in their intensity based upon the end goal of the user, and so can range from a series of packaged BMPs up to the level of a comprehensive WFP and ISO 14001 EMS (Figure 2.7). The more sophisticated on-farm QAPs take into account all of the farm's resources and activities and hence, provide tailored solutions to any environmental or production challenges present where limits are clearly defined. An unwarranted amount of criticism over QAPs is due to its ability to report progress against environmental goals. Often, however, those environmental goals are not sufficiently defined.

At present there are many packages available to hill country and steepland farmers and land managers that are a combination of these tools (Table 2.5). These packages vary in their degree of sophistication and depth, and can be tailored to suit most farm systems depending on the end goal of the user. Some packages are low maintenance and require the farmer to fill out a list of criteria and a description of their farm, and follow general BMP (LEP toolkit – Level 1, Clean streams Accord). Other packages involve more, with farmers required to attend workshops and source expert advice (LEP toolkit – Level 3, SUBS, NB and NMP's).

***Table 2.5*** *: A snapshot of some of the industry and Regional Councils approaches and initiatives that are relevant to soil and nutrient management in hill country and steepland farm systems (Sheep and Beef sector).*

| Types of Initiatives | Key aspects | Ownership/Funding | Source |
|---|---|---|---|
| **Primary Sector Water Partnership (PSWP)** | Set goals and develop action plans to address water issues in the primary industry.<br>- 80% nutrients applied to land are to be managed through a QAP nutrient budget and NMP by 2013<br>-1.7 million hectares of intensively farmed land will have an implemented management programme to minimise microbial and sediment deposition in waterways by 2016 | Fonterra, DairyNZ, Foundation for Arable Research, HortNZ, Beef +Lamb NZ, Forest and Bird, NZ Forest Owners' Association and NZ Farm Forestry Association, Fertiliser Manufacturers Research Association, Federated Farmers NZ and more. | (Primary Sector Water Partnership, 2008) |
| **The Land and Water Forum** | Government initiated group, which members represent the various groups of people that have an interest in the use and management water and hence water quality<br>- limits based regime<br>-focusing on priority catchments | Beef + Lamb NZ, Fonterra, DairyNZ, and Forest and Bird, Industry stakeholders, local Iwi (namely Tainui), universities, environmental organisations, government representatives (national and regional level) | (Land and Water Forum, 2012) |
| **Land and Environment Planning Toolkit (LEP)** | A package containing three levels of evaluation, developed to assist the sector with business and resource planning.<br>-3 levels- introductory (Level 1) through to more advanced levels<br>-tailored solutions at the higher levels | Beef + Lamb NZ, Ministry of Agriculture and Forestry-Sustainable Farming Fund | (Meat & Wool, 2008) |
| **The NZ Deer Farmers' Landcare Manual** | A quality assurance programme<br>-focuses on soil erosion and water quality issues<br>-Pasture to plate idea | NZ Deer Farmers' Association, Deer Industry NZ | (Paterson et al., 2009) |
| **Silver fern farms-Farm[IQ]** | A long term programme that focuses on the whole supply chain<br>- 7 year 'pasture to plate' programme<br>- Advocates continual improvement | Silver fern farms, Red meat Industry | (Paterson, 2012) |
| **Soils underpinning business success (SUBS)** | Farmer driven education programme where groups (8-10) attend 12 workshops to produce a farm map over a 12month period<br>- paddock scale LMU<br>- strength and weakness assessment<br>-assists in making make land use decisions and investments | MAF – Sustainable Farming Fund (SFF) | (Meat New Zealand & WoolPro, 2000) |

***Table 2.4** continued...A snapshot of some of the industry and regional council's approaches and initiatives that are relevant to soil and nutrient management in hill country and steepland farm systems (Sheep and Beef sector).*

| Types of Initiatives | Key aspects | Ownership and/or Funding | Source |
|---|---|---|---|
| **Sustainable Land Use Initiative (SLUI) - Whole Farm Plans (WFP)** | Voluntary WFP plans are produced at the request of the individual farmers or the council for farms that are in priority areas<br>-Produce a comprehensive land resource inventory of the farm (natural resources and farm infrastructure)<br>-soil map and resource capability map<br>-nutrient budget<br>-develop a works programme | Horizons Regional Council, Landcare Trust | (HRC, 2010; Mackay, 2008) |
| **Nutrient management plans** | Sets out to optimise production and maximise profit from nutrient inputs while avoiding or minimising adverse effects on the environment<br>-must comply with RMA (1991)<br>-use of OVERSEER$^{TM}$ nutrient budgets<br>-Identifies and assesses risks and opportunities according to individual farm goals<br>-Easy to follow 11 step process | Jointly owned by MAF, AgResearch and Fert Research, Used by Regional Councils throughout the country (HRC, WRC, ECAN etc.) and Fertiliser companies –Primary Industry sectors | (Edmeades et al., 2011; Paterson & Dewes, 2011) |
| **The code of practice for nutrient management** | Focuses on the use of fertiliser within nutrient management planning, occurring in wide range of land-uses.<br>-Following best management practices<br>-Nitrogen fertiliser use | New Zealand Fertiliser and Lime Research Centre (NZFLRC) | (NZFMRA, 2007) |
| **Dairying and Clean Streams Accord** | Sets out performance targets for the Fonterra suppliers to meet.<br>-Excluding stock from streams, rivers and lakes, fencing off wetlands<br>-Regular crossing points, bridges and culverts installed<br>- Systems in place to manage and monitor nutrient inputs and outputs | Fonterra, Ministry for the Environment, Ministry of Agriculture and Forestry and Regional Councils | (Fonterra, 2003) |

***Table 2.4** continued...A snapshot of some of the industry and Regional Councils approaches and initiatives that are relevant to soil and nutrient management in hill country and steepland farm systems (Sheep and Beef sector).*

| Types of Initiatives | Key aspects | Ownership/Funding | Source |
|---|---|---|---|
| **Nutrient discharge allowances (Lake Taupo example)** | Special initiative set up to reduce the amount of N entering Lake Taupo by 20% over the next few years to maintain pristine water quality<br>- Limits the amount entering through stocking rate and fertiliser application<br>-Working towards catchment scale nutrient trading based schemes<br>-Leaching limits based upon OVERSEER$^{TM}$ output<br>-Consent required if applying >75 kg N/ha/yr | Waikato Regional Council, Lake Taupo Protection Trust | (Waikato Regional Council, 2007) |
| **Market Focused 'Quality assurance scheme'** | A market focused initiative (EMS)<br>- Voluntary – mainly dairy farms<br>-Requires suppliers to maintain a database of potential threats on farm (fertilisers, pesticides, effluent disposal etc.)<br>- Farm environmental plan | DairyNZ | (Dairy and the Environment Committee, 2001) |
| **Green tick (Australian example)** | A certification system that labels a product as "environmentally OK" by providing an easily recognizable, independent, life cycle based sustainability certification of the product<br>- life cycle assessment of a products' sustainability | Green Tick Technologies Ltd. | (Harris, 2007) |

Although numerous and successful in their own right, all of these tools, initiatives and approaches are still lacking in some way when it comes to solidly addressing the main drivers for advancing SNM and the validity and reliability of the programme in the real world is under question. A review by Parminter et al. (2004) found that the range of EMS vary considerably in their content, credibility and environmental performance. Despite this, the majority of EMS reviewed have been reasonably effective in achieving their environmental outcomes when appropriately monitored and audited. There is a need for the industry and Regional Councils to review and reconsider the integrity of each of their programmes against international EMS features in the areas of auditing and validation, to determine whether they stack up against overseas programmes.

Beef + Lamb NZ have recognised the necessity for a comprehensive resource and farm planning package to address environmental issues with the farm business planning cycles. The LEP toolkit developed by Meat & Wool (now Beef + Lamb NZ), is a programme that aims to help farmers identify and address individual farm environmental and production challenges and develop tailored solutions(Meat & Wool, 2008). The LEP toolkit provides a farm plan which assesses a farm's land and environment issues using an assessment framework to address the management of environmental and production challenges. The following section gives a brief introduction into the framework of LEP toolkit and examples of its use to date.

### 3.1 Land and Environment Planning toolkit

The LEP toolkit was designed to be a more practical approach for farmers and so was developed by a mixed group of parties, consisting of seven farmers and four Regional Council representatives, and later on, industry and scientific experts. The LEP toolkit assesses the farm's resources to help farmers better understand land and environmental issues present on their farm. As each farm is unique in terms of landscape, natural resources, farm practice and economics, no two farms are alike. Therefore, there is no single framework that can be used to address land and environmental issues across New Zealand. As a result, the LEP can be tailored to an individual farming situation depending on the level of inquiry required.

There are three distinct levels in the LEP toolkit that require different information input and farmer involvement (Table 2.6). Level 1 is an introduction to the issues and can be achieved using a farm mapping method (Option 1a) or by completing a risk assessment of the farm and land resources (Option 1b). Level 2 is a more in depth analysis of the farm and its resources. The information acquired is used to identify the different land management units (LMU) present on the farm. Level 3 is a comprehensive farm plan that involves not just the farmer but also input from land management experts. The resulting report consists of a stock-take of the farm's resources, a strengths and weaknesses, opportunities and threats (SWOT) analysis of these resources, a nutrient budget, and a 'plan' outlining how these issues will be managed. Level 3 also contains a business assessment of the farm's status and so, has the ability to provide an analysis for the whole farm business enterprise. Access to any level of LEP can help farmers identify areas of land where the resources are not currently fully utilised and production opportunities are being lost and alternatively, environmental issues that need to be addressed.

***Table 2.6*** *Brief description of what is required at each level of the LEP toolkit.*

| Level | Standards | Farmer involvement | Examples |
|---|---|---|---|
| **Level 1** | Standards based on local standards (discharges, fertiliser inputs etc.) | Farmer driven- Largely 'do it yourself' | Property stocktaking, Environment Management Plans and Farm shelter Plans |
| **Level 2** | Standards based on Regional Council guidelines | Farmer driven but qualified specialist input recommended but is not required | Soils underpinning business success (SUBS) Land Management Plans (Horizons Regional Council) and the Green Project Plans (no longer in use) |
| **Level 3** | Standards based on Regional Council guidelines and National standards | Farmer driven but qualified specialist input is required | Sustainable land use initiative (SLUI) Whole Farm Plan and Comprehensive Whole Farm Plan both developed by Horizons Regional Council |

***Note:*** *For a full description see www.beeflambnz.com*

Each of the three levels (1, 2 and 3) contains three pieces of information that vary in the intensity of inquiry depending on the level:

1. A stock take of the farm's natural resources including: land, soil and water resources
2. A detailed assessment of the SWOT posed by these resources
3. An action plan stating:
   -What actions are going to be undertaken?
   -Where the actions will be focused?
   -What time frame will the actions be implemented?

There are several examples of LEP toolkit (Level 1, 2 or 3) uptake and use by Industry and Regional Councils: Shade and shelter plans, Farm$^{IQ}$ and WFP.

Farm Shade and Shelter Plans are an example of the use of LEP Level 1 – mapping exercise. Many Regional Councils (Waikato Regional Council, Horizons Regional Council, and Southland Regional Council etc.) have guidelines and self-help booklets on how to plant shade and shelter for a farm. Waikato Regional Council's "Trees on Farms" guidebook gives an outline to the planning process for planting trees for shade and shelter that involves drawing a proposed planting plan for the farm taking into consideration factors such as soil drainage, and specific site and landscape influences (Waikato Regional Council, 2002).

Silver Fern Farms is one of New Zealand's biggest red meat exporters formed in 1948 as Primary Producers Co-operative Society (PPCS). The company decided to rebrand in 2008 to the present Silver Fern Farms to reflect the shift in focus from production-based strategies to market-led strategies. The Silver Fern Farms have developed their brand over the last few years to bring added value to their end product through market strategies and promoting the idea of "pasture to plate" labelling. A pilot scheme FARM$^{IQ}$ has been running for the last two years, and combines farmers with their business manager and a working group of specialists to highlight production opportunities at minimal cost to the environment (LEP - Level 2). The FARM$^{IQ}$ scheme also has a database that allows the participating farmers to analyse and benchmark their performance against themselves and their peers over a series of inputs and outputs (Paterson, 2012). The idea behind FARM$^{IQ}$ scheme is that by ensuring effective and informed decision-making around the environmental and production issues will result in an end product that is more closely aligned with market place requirements and hence have access to niche markets (EU). At present Farm$^{IQ}$ has an uptake among farmers with around 400 or so signed up (Paterson, 2012).

Horizons' WFP is an example of the applicability of Level 3 of the LEP toolkit. The Horizons' WFP was first developed by SLUI following the 2004 Manawatu floods, to protect and future-proof the region's hill country assets from future storm events. The purpose of the plan is to identify farm-specific opportunities, focusing primarily on resource conservation (land, water, vegetation) and sediment management, but also extends into sustainable business development, in recognition that in a farm system the environment and farm business cannot be treated separately (Mackay, 2008). The original goal for the Regional Council was to achieve 1,500 plans over the next 10 years, with half of these plans done on farms defined as in the most at risk locations (priority catchments). To date approximately 400 plans have been completed covering a total of >300,000 ha of the region *(A. Mackay Personal communication 12$^{th}$ March, 2013)*.

## 4. Summary

This study concludes that there are many complex and interrelated drivers for advancing soil and nutrient management. The understanding of the drivers for both farmers and the industry is crucial to the future success (overall productivity and environmental stability) of the sector. Key points noted from the literature review are summarized below under the key topic headings: 1) freedom to operate, 2) nutrient use efficiency, 3) ability to demonstrate sustainability, and 4) current tools available to New Zealand Sheep and Beef farmers.

### 4.1 Freedom to operate

- The RMA is meant to manage the use, development and protection of the soil, however, current NPS, and Regional Plans captures the activities that impact on the environment and so it is an effect based regulatory environment.

- The RMA deals less with SNM than its predecessors.
- Regional Plans state the activities that are permitted to occur under the condition that adverse environmental effects are "avoided, remedied or mitigated."
- Regional Councils in the past mostly rely on BMP's to regulate nutrient use. Exceptions include: N use (150-200kg N/ha/yr and a NMP required for applications >60 kg N). Limits on N use and looking forward to future N limits in sensitive or priority catchments (nutrient caps – Lake Taupo, Lower Rangitikei, Mangatainoka etc.) are becoming an increasing feature in Regional Councils.
- Rules and regulations around erosion and sediment loss (discharges to water, land disturbance and riparian zone management), are based only around the activities that can cause erosion and sediment loss, and not specific sediment and nutrient loss limits. Some Councils e.g. HRC, have stricter rules around land defined as being highly erodible (HEL), and others have regulations that stipulate more accurate LUC mapping required for areas classed as VIIe and above (Gisborne District Council). There are no solid rules around livestock access to waterways; instead Councils rely on BMP and voluntary compliance.
- There are many initiatives that focus strongly on land use and BMP. Horizons Regional Council's proposed OnePlan has regulatory and non-regulatory approaches to managing soil and nutrient management issues (SLUI, WFP, FARMS etc.), that focus on nutrient budgets and nutrient management plans to address and manage the SNM issues.

### 4.2 Nutrient use efficiency

- Nutrient inputs, cycling, and transformations involving interactions between the soil, plants and grazing animals result in losses that then require nutrients to be applied to the soil (fertilisers) to maintain soil levels for optimum pasture production.
- Fertiliser P is used more than N fertiliser in Sheep and Beef farm systems, therefore P accumulation and loss is more of an issue in hill country and steepland landscapes than N loss.
- The nutrient issues in hill country and steepland landscapes are more concentrated around the issue of nutrient transfer between landscape units and the uneven return to campsites (100% of P returned in dung, and 40-80% of N returned in the urine to camp sites) from the grazing animal. Therefore, nutrient management issues surround critical source areas where nutrients accumulate (e.g. stock camps, tracks etc) are more susceptible to nutrient loss (surface runoff and nitrate leaching) that can result in degradation in water quality.
- Extended periods of high fertiliser application (namely P fertiliser) can lead to Cd and F loading of the soils. Although in Sheep and Beef farm systems, the application rate is not high enough that Cd will accumulate to above SGV (1mg Cd /kg).

### 4.3 Demonstrated sustainability

- Sustainability is a very hard concept to define but sustainability on a farm scale is generally focused around the farm's biophysical system and impacts on the environment.
- Food sustainability (animal health and safety, identification and traceability) and public perception are key market drivers of sustainable agricultural practices which have resulted in many EMS, QAP's and Eco-labels to ensure the environmental friendliness of the product. However, the overall reliability of these schemes is variable and hence, the resulting product is unreliable. The ISO 14001 standard is the most internationally recognised and accredited EMS scheme. The standard requires a "plan, do, check and act" set of criteria.
- In New Zealand, the driver for advancing and improving soil and nutrient management has come from industry bodies (Beef + Lamb NZ, fertiliser companies etc.) by developing codes of practice and guidelines, largely based upon BMP's to reduce the impact of their sector on the environment.
- The cost of implementing the additional non-regulatory methods for demonstrating sustainability (EMS, QAP's etc.), is low on farmers' (and industries') priority list, and so will not be enough on their own to significantly improve their farming practices, if it compromises the growth of their farming business.

### 4.4 Current tools available to New Zealand Sheep and Beef farmers

- Soil and nutrient management tools are generally initiated by industry driven motives such as promoting the sector/company to the wider public and improving public relations and the industry's image. These are also endorsed by many Regional Councils e.g. Horizon's Regional Council.
- The tools are packages involving various combinations of the tools, (BMPs, NBs, NMPs, WFPs and QAPs), that can either give generic information (BMPs), or site and farm specific information and recommendations (WFP) depending on the activity that they are trying to control using a non-regulatory approach.
- Although there are numerous tools available (Table 2.4), their validity and reliability when applied in the real world is questionable. The framework for an EMS was found to be the most effective at achieving their environmental outcomes.
- LEP toolkit was designed to be a more practical approach for the Sheep and Beef sector to help farmers with business and resource planning. The toolkit uses a step-by-step guide through a choice of three levels that provide a farm plan that can be tailored for individual farming situation depending on the level of inquiry required.

# Chapter Three Research design

## 1. Introduction

This chapter describes the investigative technique used. This research problem is multi-faceted and uses both quantitative and qualitative methods, including a case study and interactive workshops, to determine the utility and efficacy of each of the three levels of the Beef + Lamb NZ Land and Environment Planning Toolkit (LEP) for advancing nutrient management. The case study included hands on fieldwork, data acquisition and in-depth field interviews. Direct observation, notes and worksheets were used in the two LEP workshops run by Beef + Lamb NZ. The information obtained from each step of the process included: the current knowledge and understanding at each of the three levels of the toolkit in terms of soil and nutrient management (SNM) issues, the strategies employed to help address SNM issues, and the farmers overall understanding of the process.

The first section of this chapter discusses the research design and why this was chosen. The second section introduces the case study farm and the farm's resources. The third section describes how each level of the LEP toolkit was applied to the allocated farm (Springvale Station) and explains the steps that were used to collect information. The fourth section describes how the workshops were run and how information was collected to reinforce information gathered during the case study. The final sections describe how the data was collated, analysed and presented.

## 2. Qualitative research design

An interpretive framework alongside an evaluation process (programme evaluation) was used as the research method in this study. The main objective of the study was to determine using a stepwise approach, if the three levels in the Beef + Lamb NZ- LEP toolkit progressively add the elements, flexibility and rigour necessary to address the current and future drivers that will shape SNM for hill country and steepland farmers. This was tackled through 1) A case study involving a commercial Sheep and Beef farm with both the farm manager and supervisor interviewed and 2) Two LEP Workshops organised by Beef + Lamb NZ involving a total of eight farmers.

**Case study farm**: The three levels of the LEP toolkit were evaluated in a stepwise analysis using the biophysical, production and field information and interviews with both the farm's manager and the farm supervisor from the case farm.

**Workshop:** Two LEP Workshops run by Beef + Lamb NZ were used to evaluate the LEP toolkit with eight of the participating farmers through recorded observations and a series of interviews. For both approaches, the value and efficacy of the information gained from the farm plan for each level of the LEP toolkit was assessed against the on-farm issues and the wider operating environment. These two approaches were chosen for their interpretive framework which allowed the research to be flexible and subjective, a crucial feature in this pilot study.

# 3. Case study farm: Springvale Station

### Introduction

Springvale station is situated approximately 40 km north east of the Taihape Township on the Taihape-Napier Road in the Rangitikei District of the Manawatu-Wanganui region (Figure 3.1). The station has been managed by the Lascelles family for the past 17 years and operated by Rimanui Farms Ltd. (supervised by Lester Wright) for the past 10 years.

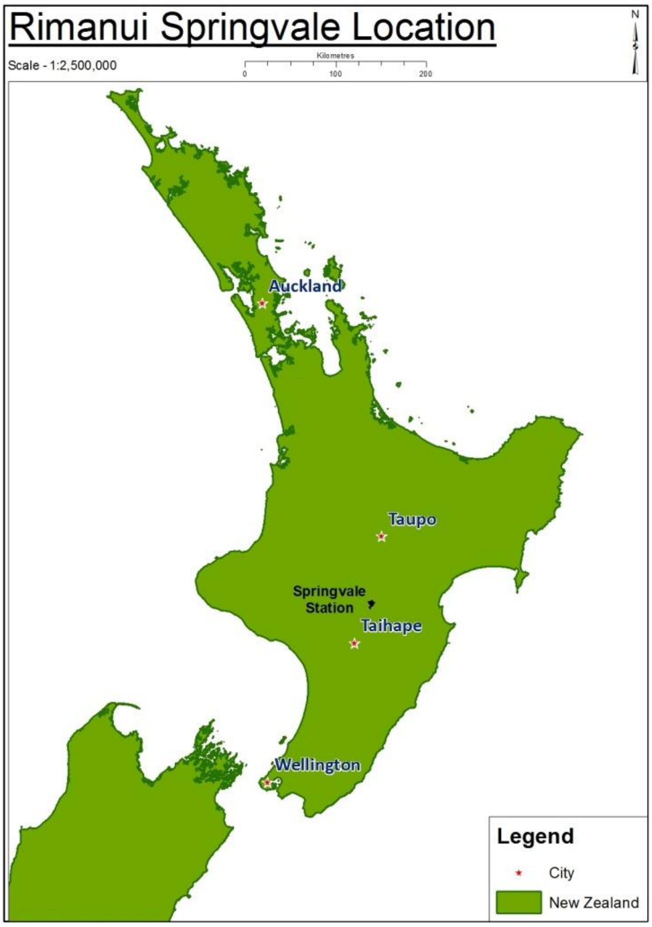


***Figure 3.1*** *Location of the case study farm Springvale Station.*

The station has a total area of 3,201 ha (2,900 ha effective) which has a mixture of topography ranging from river flats to plateaus with the majority of the farm located on land classified as either strongly rolling (49%), moderately steep or hard steep hill country (24%).

The underlying geology of the area consists of a mixture of sandstone, jointed mudstone and siltstone and some conglomerates found in the steep hill country. The rolling hill country is largely mantled with andesitic tephra deposits and the flats are a mixture of tephra deposits, gravels and alluvium. The soils are of sedimentary and volcanic origin that formed under native forest that was cleared and put in to pasture approximately 100 years ago.

The station is run as a sheep/beef breeding and finishing farm producing approximately 8,300 kg of pasture DM $ha^{-1}$ $yr^{-1}$ pasture and running 29,857 stock units (SU) per hectare (59:41 sheep: beef ratio) which equals a stocking rate of approximately 10.2 SU $ha^{-1}$. The main flock consists of Romney, while the breeding herd is predominantly Angus/Hereford crosses.

**Topography**

There is a range of topography on Springvale station. More than 50% of the station is located on land classified as rolling, hilly or steep (LUC slope class A-D). Remaining land types consist of alluvial river flats, hill plateaus, middle flats and easy rolling country (LUC slope class E-G)

**Climate**

The climate of the area is characterised by long cold winters with annual snow storms common. Intense rainfall events are rare. The temperature has an annual average of around 9°C with an annual potential evapotranspiration (PET) of between 651-800. Long-term average rainfall is 950mm rainfall, low seasonal variation ranging between 900-1000mm across the farm. Although water deficits occur occasionally in the summer months, and the farm has suffered droughts recently, more frequent (2007 and 2013), droughts are normally uncommon. The altitude ranges from 850m on the river flats to approximately 1000m on the hill tops.

**Geology**

The area of land containing Springvale Station in tertiary times was under water and part of a large ocean basin. The basin was filled with considerable quantities of mud, sand, shells and gravel deposits that over time was consolidated and lithified to form the mudstone, sandstone, limestone and conglomerate deposits that are characteristic of the area (Fleeming, 1953). As a result the underlying geology of the Springvale area consists of a mixture of moderately consolidated to consolidated sandstone, jointed mudstone and siltstone, greywacke and conglomerates found in the steep hill country with some pebbly limestone that outcrops as rim rocks (Matemateaonga Formation) (Vonk & Kamp, 2004). The easier hill country and lower lands are comprised largely of andesitic tephra deposits and the terraces and flats are a mixture of airfall and water-laid tephra deposits, gravels and alluvium. Wetlands make up approximately 50 ha of the areas and were formed from peat accumulation and tephra deposits (Campbell, 1978). On a regional scale, there is quite a range of geology, from sandstone/ mudstone/ alluvium/ and ash. On an A1 map of New Zealand geology, the main parent rock types on Springvale are, limestone, Kaharoa and Taupo ash (Kt), Sandstone - ashes older than Taupo (Mo) debris outwash, and gravel (Figure 3.2).

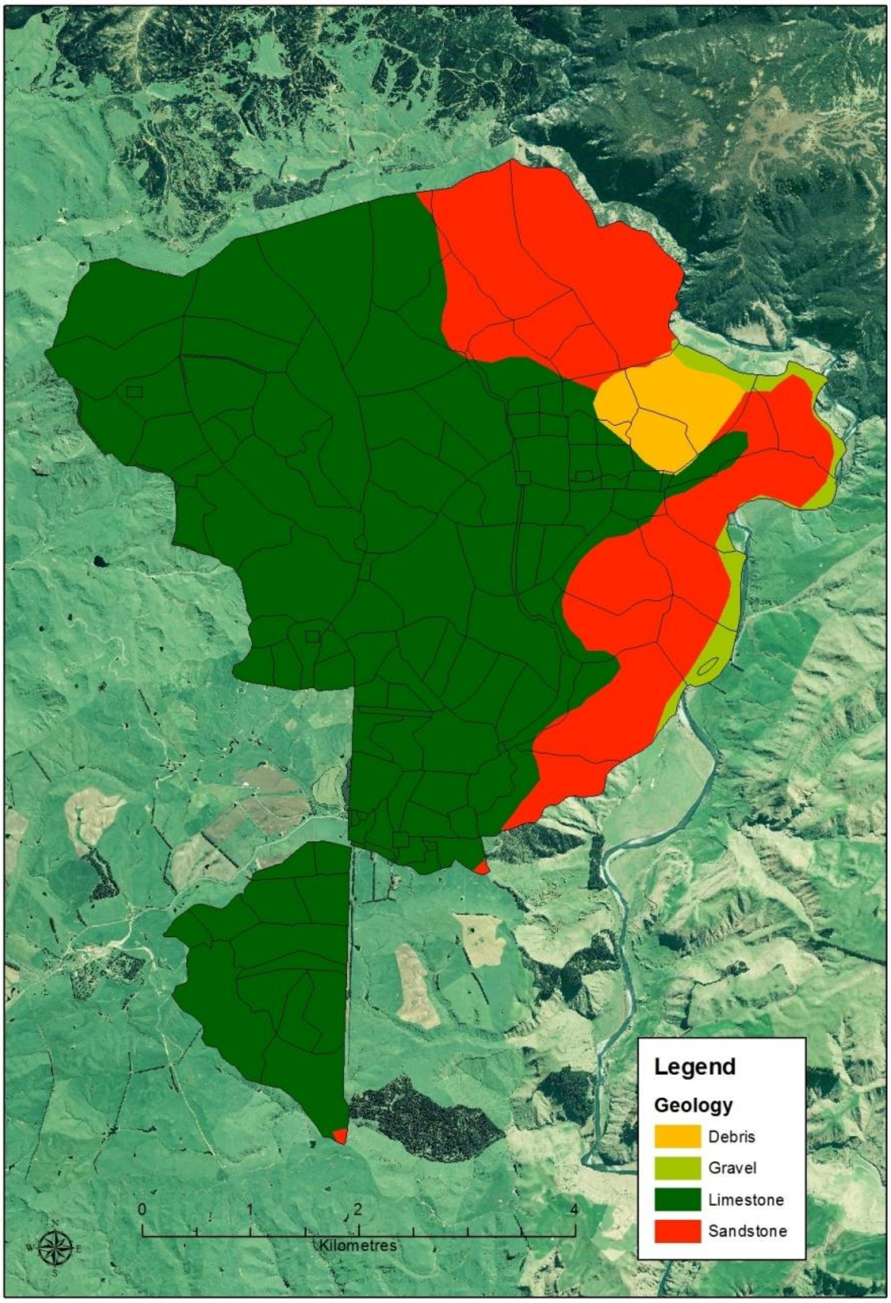


***Figure 3.2** Local geology of the case study farm Springvale Station*

***Source:** Lee et al., 2011*

**Soil types**

The dominant soil series on the station is the Moawhango Series. The parent materials derive from andesitic tephra deposits over a sandstone, siltstone and mudstone base. The most common soil type present on the station according to NZLRI was the Moawhango Sandy loam (Yellow-brown loam (Cowie & Campbell) classed as an Orthic Allophanic Soil (Hewitt, 1998) There are two main soil divisions based on topography recognised within the Moawhango series: Moawhango Sandy loam phase (Mw) and Moawhango hill soil, Sandy loam phase (MwH). The Mw is located on the flat to rolling surfaces of the north-eastern uplands and high terraces of the Taihape region, as well as the toes slopes of the central steepland in the north of the region. The MwH on the other hand is located on the moderately to steep slopes of the Taihape region (Campbell, 1978).

Both these soils were derived from deposits from the Tongariro ash, which is a principal parent material of the soils in the area. The Tongariro ash largely comprised post Kawakawa andesitic and rhyolitic tephras with traces of rhyolitic ash from the Taupo Tephra Formation deposited c. 232 AD in the upper horizons (Hogg et al., 2009; Sparks et al., 1995). These soils are extremely versatile with moderate natural fertility and a free draining profile that is suitable for high producing pasture along with root and green fodder crops (Cowie & Campbell).

The Moawhango Sandy loam is very resilient and versatile, however, due to its volcanic nature; it has a high concentration of the clay mineral allophane and hence, has a high fixing power for phosphate. As a result, large and frequent applications of phosphatic fertilisers are required, in addition to potash (potassium based fertiliser) to main optimum pasture growth. The other soil limitation present is high altitude and very cold winters. The Moawhango soil series can be further divided into other soils deduced from Campbell (1978) and Fletcher (1987) (Figure 3.3, Table 3.1).

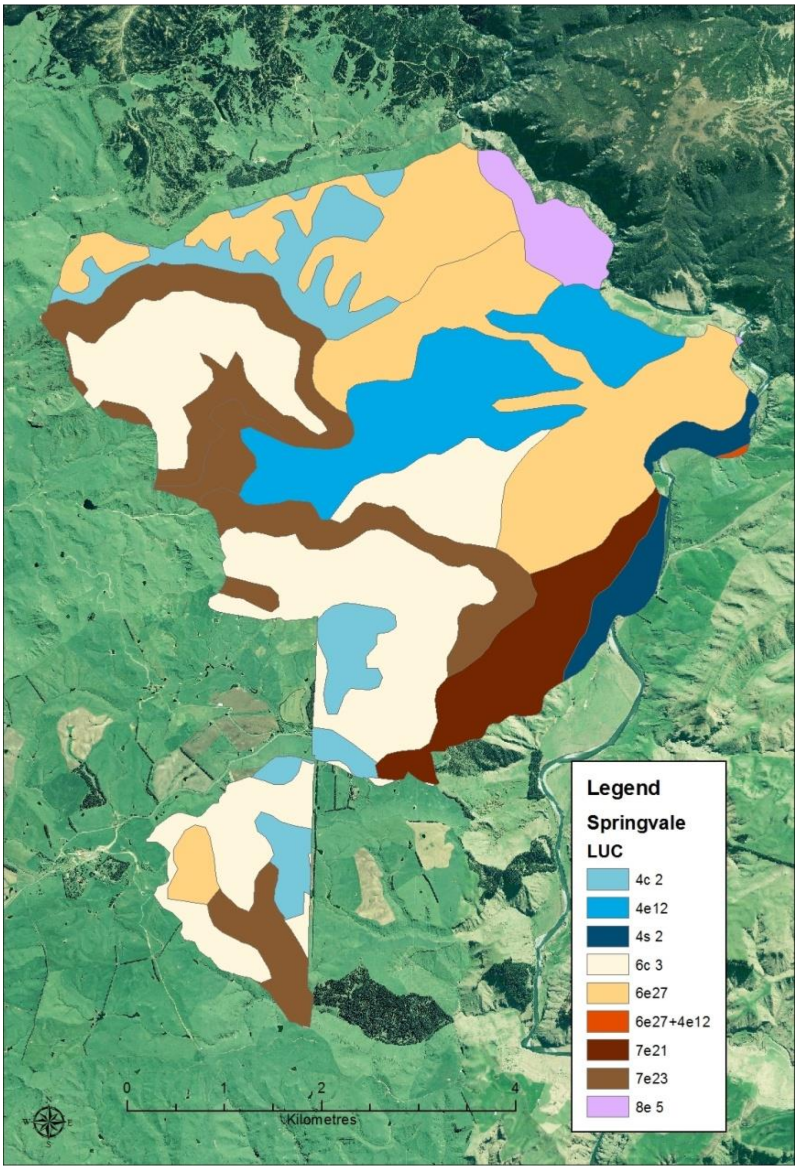


***Figure 3.3*** *Land Use Capability classes present on Springvale Station*

***Source:*** Landcare Research, 2013

***Table 3.1*** *A selection of the suite of LUC present at 1:6,500 scale for the landscapes of Springvale Station*

| Soil series | LUC classes |
|---|---|
| Soils on greywacke (sandstone) | VIIIe5 |
| Soils on jointed mudstone/siltstone | VIe3 |
| Soils on Colluvium | IIIw2 |
| Soils on wetlands | VIc3, VIIw1, VIIIw1 |
| Soils on the lower river terraces | IVe12 |
| Soils on the gravel terraces | IIIe8, VIs7 |
| Soils on alluvium | VIe27 |

***Source:*** *Fletcher, 1987*

### Resource evaluation

The 3,201 ha station (2,900 ha effective) carries 29,857 Stock units (10.2 SU $ha^{-1}$) mostly as sheep). Romney is the dominant sheep breed and Angus/Hereford beef for the cattle with approximately 49% of the stock being made up of cattle and the remaining 51% being made up of sheep. The main flock is Romney (consistent >100% lambing), while the breeding herd is predominantly Angus/Hereford crosses. Table 3.2 shows the most recent stock resource evaluation for Springvale Station.

***Table 3.2*** *Stock resource evaluation* June *2011*

| Stock type | Number of stock June 2011 |
|---|---|
| **Sheep** | |
| Mixed age ewes | 10,160 |
| Two-tooth ewes | 3,872 |
| Ewe hoggets | 5,032 |
| Breeding rams | 210 |
| Sheep stock units | 17,722 |
| **Cattle** | |
| Mixed age cows | 706 |
| R2 heifers (in calf) | 160 |
| R2 heifers (empty) | 194 |
| R1 heifers | 363 |
| R1 steers | 374 |
| R2 steers | 544 |
| Breeding bulls | 19 |
| Cattle stock units | 12,135 |
| **Summary** | |
| Total stock units (SU) | 29,857 |
| Sheep: cattle ratio | 59:41 |

***Source:*** *K. Lascelles (personal communication, 19th July, 2012)*

Currently the farm has approximately 150 paddocks but the number is increasing as the paddocks are further subdivided (Figure 3.4). There is a wide range of paddock sizes with some as small as 1.76 ha and the largest at 136.5 ha, with the average being 24.5 ha (SD 21.8). The average pasture production is 8,300 kg DM $ha^{-1}$, based upon a stocking rate of 29,857 equivalent SU and approximately 60-70% pasture utilisation. Cropping is a significant enterprise on the farm with approximately 131 ha of land in crops at a time. Crops grown throughout the year include maize silage and fodder crops such as Swede (108 ha) and Rape (23 ha). The Swede crop is cultivated in November of the proceeding year via conventional methods, and is used as a fodder for the winter months of June and July producing an average 14 T DM $ha^{-1}$ a year. The Rape crop, on the other hand, is first cultivated (conventional) in November and then grazed from February through to July, producing approximately 10 tonnes DM $ha^{-1}$. Both crops are resown into pasture in October. At present there is no form of irrigation on the farm.

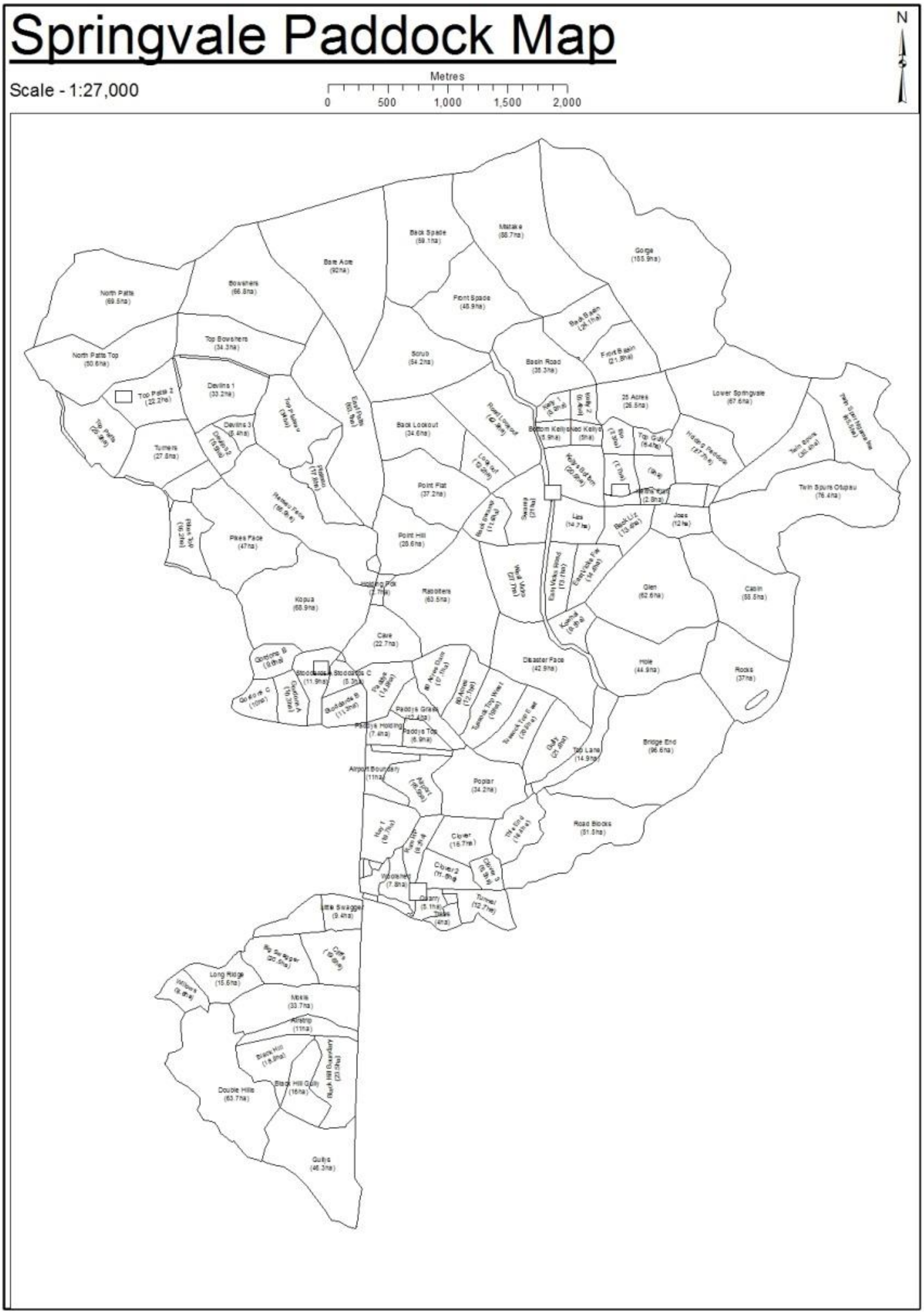


***Figure 3.4*** *Springvale Stations paddock layout (2012)*

***Source:*** *K. Lascelles 2012*

Fertiliser and nutrient management

Historically, the farm is split into nine nutrient management blocks based upon differences in the land-use and pasture production. In addition to these nine blocks (Plateau Block, Patts Face Block, Back Pumice Block, Middle Hills Block, Middle Flats Block, River Country Block, Top Terrace Block, Black Hills Block and a Non-effective Block), there are two sub blocks containing forage crops of Swede and Rape (Figure 3.5). Soil tests for the average soil nutrient levels show that the farm has a range of fertility levels, most of which are within the optimum range for pasture production. The fertiliser management policy 2011/2012 is shown in Table 3.3.

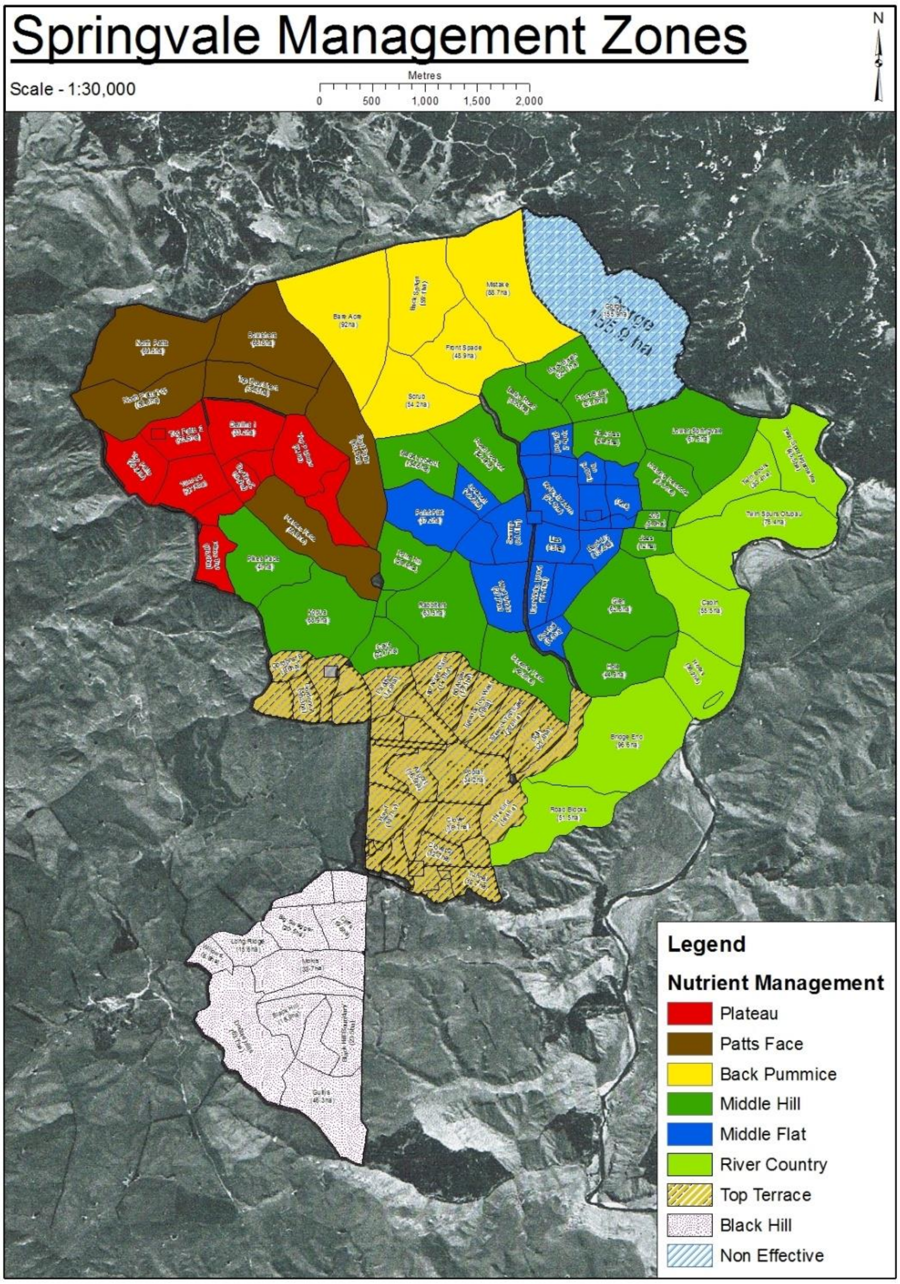


***Figure 3.5*** *: Current fertiliser policy for the Springvale Station over the last 12 months (2011/2012)*

***Source:*** *Ravensdown Ltd. B. Meyer (Personal communication, 4th May, 2012).*

***Table 3.3*** *Fertiliser policy Springvale Station (2011/2012).*

| Block | Fertiliser | Rate | Area |
|---|---|---|---|
| **Plateau** | None | - | 200 ha |
| **Patts Face** | Superphosphate | 200 kg $ha^{-1}$ | 380 ha |
| **Back Pumice** | Cropmaster DAP | 100 kg $ha^{-1}$ | 340 ha |
| **Middle Hills** | None | - | 639 ha |
| **Middle Flats** | Superphosphate | 250 kg $ha^{-1}$ | 240 ha |
| | Urea | 80 kg $ha^{-1}$ | |
| **River Country** | Superphosphate | 200 kg $ha^{-1}$ | 451 ha |
| **Top Terrace** | Superphosphate | 250 kg $ha^{-1}$ | 355 ha |
| **Black Hill** | Cropmaster DAP | 100 kg $ha^{-1}$ | 295 ha |
| **Swede** | Cropmaster Brassica | 250 kg $ha^{-1}$ | 108 ha |
| **Rape** | Cropmaster Brassica | 250 kg $ha^{-1}$ | 23 ha |

*Note: All fertiliser and soil test information sourced from Ravensdown Ltd. B. Meyer (Personal communication, 4th May, 2012)*

## 3.1 Stepwise evaluation of the Land and Environment Planning tool kit

### Evaluation of Level 1

Level 1 of the LEP assessment can be completed through two methods depending on the individual farmer's preference. Option 1a) Farm mapping method was completed using an orthophoto or farm aerial photo, and Option 1b) Risk assessment method if no image of the farm is suitable or available (Figure 3.6). For this exercise both assessments were carried out during the initial farm visit on the 14th March 2012.

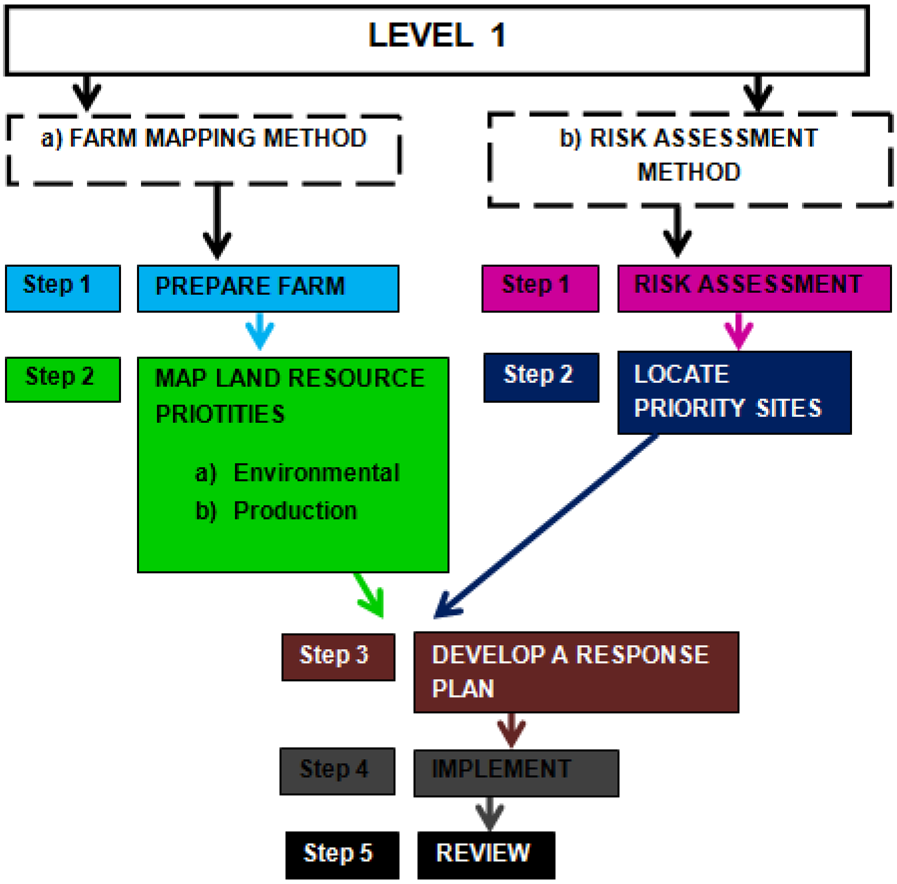


***Figure 3.6*** *Outline of steps taken for Level 1 evaluation*
***Source:*** *adapted from Beef + Lamb NZ, 2012.*

The supervisor and farm manager completed both options independently. For each assessment, a time limit of approximately 30 minutes was given to complete each section before moving onto the next part of Level 1. Their answers were recorded and categorised to attain an overall indication of their view of the farms environmental issues faced at present and, potentially, in the future.

### Option 1a) Farm mapping method

The participants used two blank paddock farm maps to produce an environmental issues map and a productive capability map. The first farm map identified any environmental issues that they perceived to be on the farm, both those present and any potential issues on the farm in the future. The second map was used to help the participants to identify the production classes of the land and where it is not performing to its optimum potential. Coloured markers were used to separate the identified issues and highlight any areas of concern. Both responses were combined to produce an overall map that displayed environmental and production issues on the farm.

**Option 1b) Risk assessment method**

The Risk assessment method provided a step-wise approach, answering either yes or no to a series of questions in a survey to help to identify environmental issues commonly faced on Sheep and Beef farms and the degree of risk these on-farm issues posed to the environment. The questions proposed were under a series of four key themes including:

- Water Quality
    - Nitrogen
    - Phosphate and Faecal bacteria
- Productive Capability
- Erosion
- Other issues not yet addressed

For consistency and the ability to obtain all information available, both the farm manager and supervisor answered option B) separately but under the same conditions. The response for each question was recorded and any more information noted down for later use. If the participant answered YES for a question, a red dot was put in the rating box. As a general basic standard of the LEP Toolkit, if there is one or more 'red dot' for each category (Nitrogen, Phosphate, Productive Capability etc.), it was suggested that the farm may have an elevated risk for that nutrient and may require further investigation to manage the risk.

A response plan was first discussed and then designed in agreement by both participants to address the answers given and the environmental and production issues raised in both option 1a and 1b of Level 1 assessment of the LEP.

**Evaluation of Level 2**

Level 2 was completed in addition to using the information gained during the completion of the Level 1 assessment, using a stepwise approach to identify the different land management units (LMU) shown in Figure 3.7. This was done using a combination of land resource mapping and farm data, to group similar land types as a series of individual LMU that represent the farm.

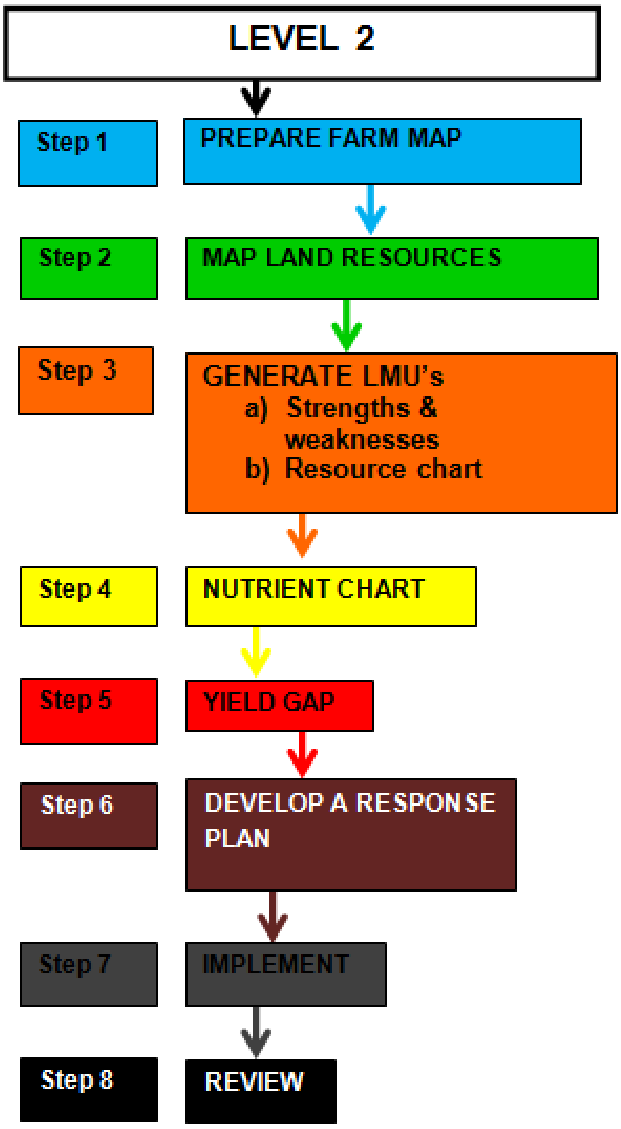


***Figure 3.7*** *Outline of the steps taken for level 2 evaluation.*

***Source:*** *(Beef + Lamb NZ, 2012).*

Once identified, each LMU was analysed to determine the strengths and weaknesses presented and once finalised, recorded in a resource management chart. A nutrient budget was prepared for each LMU using the fertiliser and soil nutrient information obtained from a Ravensdown fertiliser representative (*Personal communication, 4th May, 2012*), and the nutrient budgeting software OVERSEER™ (Version 6.0) (2012). From this analysis an estimation of the whole farm's production and the yield gap between the whole farms' potential production was determined. The last step of the Level 2 assessment involved developing a response plan similar to Level 1 assessment that outlines the strengths and weaknesses of the farm system.

For consistency and accuracy both the supervisor and farm manager were involved in the discussion at the same time. The following steps were involved to obtain the information required to complete the Level 2 assessment of the LEP toolkit.

**Step 1- Prepare farm map**

An aerial photograph of the farm and a copy of the farm paddock map were obtained from the Googlemaps.com database and the farmers' records. Using the aerial photograph and farm map, the main features of the Springvale Station both infrastructure (fences, roads, shelter belts, stockyards) and natural resources (wetlands, streams, forestry) were mapped onto the farm photo.

**Step 2- Map the land resource**

Using differences seen by the naked eye to the landscape such as geology, morphology, slope and other noticeable physical factors, the land was divided into primary landforms:

- Flats, hills, gullies, river flats
- Different slopes and aspects
- Elevation

Using these primary landforms, additional physical differences such as soil type, drainage, aspect, elevation and ability to be ploughed were identified within each landform and used to split them into further subdivisions called land type. The differences in the management of the land type were assessed and a series of strengths and weaknesses identified for each land type.

**Step 3- Land Management Units (LMU's)**

**a) Identification and Design of LMU's**

By grouping together the areas on Springvale station that have similar land types and hence, management units, a more manageable set of Land Management Units were designed.

**b) Evaluation of LMU's and Resource chart**

The strengths and weaknesses of each LMU were determined through analysis of the resources and through discussions with the farm supervisor and farm manager, and presented in a table. A resource chart was drawn up from the evaluation of the LMU in the previous step and used to visually represent the results of Level 2 assessment.

**Step 4 – Nutrient Budget**

Preliminary analysis of Springvale Station's nutrient resources was carried out using the nutrient budgeting model tool OVERSEER™ (2012). As information regarding the nutrient status of each LMU of the farm was unavailable, the farm's paddocks were split into blocks based upon the topography of the land. This decision was made largely due to information regarding topography as the most influencing factor on nutrient management in OVERSEER™ (J. Hanly – personal communication 22/06/2012). The total area of each block, comprising the different topographies, the type, the fertiliser rate applied to each block, and the monthly stock reconciliation was determined using information given in the farms' Ravensdown parameter report. Using this information a nutrient budget was produced for each of the determined blocks and for the whole farm.

**Step 5 – Yield gap**

a) Whole-farm pasture yield

The current whole farm pasture yield per hectare was calculated by determining the stock units for the farm and converting the stock units into dry matter demand. For Springvale Station an utilisation factor of 0.7* (utilisation percentage of 70%/100) was used to represent the whole farm. Using the equation below the whole farm pasture production was calculated.

| **Stock units** | | | **Utilisation factor*** | | **Whole farm yield** | | **Effective area** | | **Yield per ha** |
|---|---|---|---|---|---|---|---|---|---|
| [ ] | **x 550** | ÷ | [ ] | = | [ ] | ÷ | [ ] | = | [ ] |
| *Total SU* | | | | | *Kg DM/yr* | | | | *kg* |

The value given by the kg DM $ha^{-1}$ $yr^{-1}$ represented the minimum amount of pasture that the farm must grow per hectare to sustain the current stocking rate.

**Step 6 – Response Plan**

A response plan was designed in agreement with both participants to address the issues raised as a consequence of completing the Level 2 assessment.

**Step 7 & 8 – Implement & Review**

Outside of the confines of this research and so will be discussed no further.

**Evaluation of Level 3**

Level 3 of the LEP toolkit was carried out using the information gathered in Level 1 and 2 assessments as a basis for the Level 3 assessment. Hereby following steps outlined in Figure 3.8, a whole farm plan was produced.

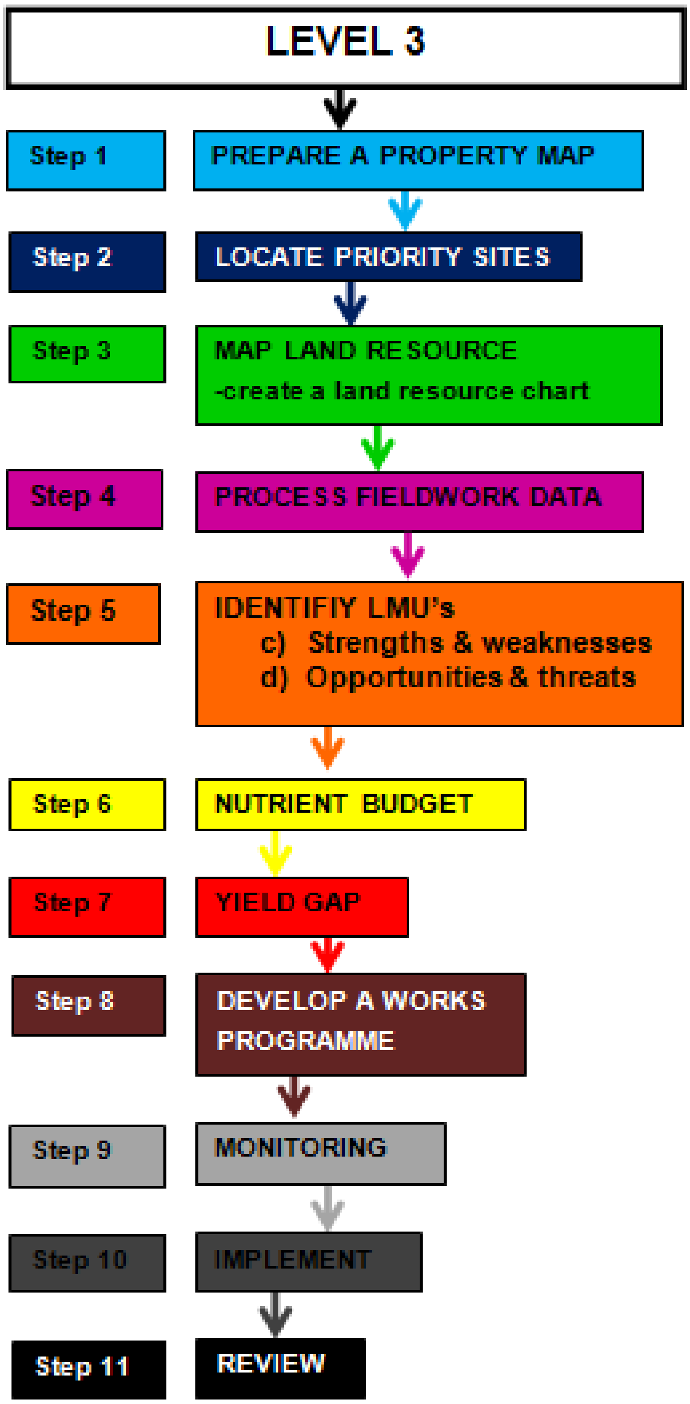


***Figure 3.8*** *Outline of the steps taken for level 3 evaluation.*

***Source:*** *adapted from Beef + Lamb NZ, 2012.*

**Step 1- Prepare a property map**

Similar to the steps taken in Level 1 and 2 assessments, an aerial photograph of the farm and a copy of the farm paddock map were obtained from the Googlemaps.com database and the farmers' records, in addition to a map for the nutrient management blocks for the farm sourced from Ravensdown fertiliser representative for the farm *(Personal communication, 4th May, 2012)*.

**Step 2- Locate land and environmental priorities**

Using the resources stated in step 1, the main features of the farm, both infrastructure (fences, roads, shelter belts, stockyards) and natural resources (wetlands, streams, forestry), were mapped onto the farm photo.

**Step 3 – Map the land resource**

The mapping exercise consisted of three full days in the field with assistance from both Horizons and Landvision staff carried out 14$^{th}$-17$^{th}$ May, 2012 (Table 3.4).

***Table 3.4*** *Details of fieldwork carried out 14th-17th May 2012.*

| Day | Mapping details | Corresponding map blocks |
|---|---|---|
| **1 – Monday** | Mapped the southern part of the farm across the road - Erewhon Station | 6 |
| **2 – Tuesday** | Mapped the northern and middle part of the farm | 1, 2, 3 |
| **3 – Wednesday** | Mapped the eastern, the river flats and southern part of the farm north of the road | 4, 5 |
| **4 – Thursday** | Mapped the remainder of the farm | |

The mapping exercise started with defining the boundary between units by differences in topography and vegetation. The land resource was then described and evaluated according to the Land Resource Inventory (LRI) and LUC Classification as a guide (Lynn et al., 2009). The land resources survey was undertaken at a 1:8,000 scale. Brief soil profile descriptions were noted from natural exposures for each unit where possible.

a) GPS

A GPS point was taken at each location for a photo, soil profile or description of a different unit. Each GPS point was recorded in a log book with the following information: i) what the GPS point was in regard to and ii) any additional information of interest.

b) Description of LRI information

At each site the parent material, soil type, slope, erosion and a number of other characteristics about the site were recorded and given a number (Horizons SLUI whole farm plan monitoring form).

c) Soil profile

At each site where a soil profile was taken, a description of each horizon and their properties were recorded and an annotated diagram of the soil profiles drawn.

**Step 4 – Fieldwork data processing**

The processing of data acquired by Landvision was used to create the LUC map and other maps (pasture production, soil maps) required for the WFP were obtained from

D. Benn (*Personal communication, 7th August, 2012*). An outline of the steps taken is summarised below.

1) The maps drawn in the field are converted into a digital format by a GIS technician who digitises up the field sheets onto ArcMap and identifies the boundary of each unit (polygon) and defines it as a separate polygon.
2) The individual polygons are given attribute tables that contain all the information gathered both through the council and farm resources and out in the field during the mapping exercise. This includes but is not limited to; all of the LUC & LRI data; some Horizons Regional Council measurement/assessment data; location and date of mapping and calculated areas for each polygon.
3) The attribute tables of each unit are then exported to Excel and run through a pivot table to identify areas within each unit that have similar descriptions e.g. vegetation classes, slope classes and erosion severity. Those identified as having the same or similar attributes by the pivot table were grouped together, defined by their differing characteristics (soils, vegetation, land use, pasture production etc.) and re-defined as the different LUC units.

Thereby following the steps 1-3, the final fieldwork map was divided into LUC's via a pivot table analysis based upon the comparable attributes within the descriptions of the individual units and combined to produce an LUC map. This map was converted into a digital format using ArcMap GIS and used to display the different LUC units in the final whole farm plan (Appendix 1).

**Step 5 – LUC units and SWOT analysis**

A description of each land resource on the farm and the different LUC units they contained was done with an assessment of the resource in terms of strengths and weaknesses, and any opportunities or threats present (SWOT). This was presented as a resource management chart in the final report.

**Step 6 – Nutrient Budgeting**

The nutrient budget was determined using the current fertiliser and soil nutrient inputs sourced from Ravensdown fertiliser representative and the production levels estimated using OVERSEER™ (*Personal communication, 4th May, 2012*). See appendix 1 for details Future nutrient management recommendations made for the property in the report are based upon future projections of pasture production for the soil, aspect, slope and potential stocking rates data presented in the final plan.

**Step 7 – Determining pastoral yield gap**

The yield gap was determined using a similar process to the calculation used in Level 2. In addition to this, a current and potential scenario was developed for the overall pasture production and stock carrying capacity of Springvale Station. The potential carrying capacities (sourced from LUC extended legend) and current stocking rates were correlated with the areas of land defined as effective for pasture production extracted from the pivot table. The pastoral yield gap was then determined from the difference between the existing and potential levels of pasture production for different parts of the farm.

**Step 8 & 9 – Develop a works programme & Monitoring programme**

After the fieldwork for the WFP was completed, a works programme and monitoring programme was designed by Landvision in agreement with both the farmer/land manager and Horizons Regional Council's Environmental Management Officer to address the issues raised through the completion for Level 3.

**Step 10 & 11 – Implement and review**

Outside of the confines of this research and so will be discussed no further.

## 3.2 Data collection

Data were collected in two parts: through a case study farm and interactive participation in the LEP workshops. Primary data was collected during the fieldwork and interviews on the case farm, and during the LEP workshop meetings and immediately following through interviews. Where possible, copies of original records were collected from the farm manager. This direct contact ensured that all the information required by Levels 1 and 2 of the LEP was collected and allowed follow-up questions to be asked. Contact with the farm supervisor and manager was maintained throughout the research process. This allowed the researcher (author) to ask questions for clarification and make further requests and ensured that the farmer understood and contributed to the development of the plan and hence had a sense of ownership to the overall process. The final draft document of the results from Level 3 (Springvale Station WFP) was sent to Horizons Regional Council for their input and for discussion with the farmer before being published.

## 3.3 Analysis

The fieldwork data and observations for all three levels of the LEP assessment was analysed according to the Boyatzis (1998) method for code development. Coding is the process of examining raw qualitative data in the form of words, sentences and experiences and assigning codes or labels to categorise the response (Becker & Geer, 1957; Boyatzis, 1998; Charmaz, 1983; Strauss, 1987). Although not strictly a traditional coding method, the coding strategy was used to organise the results of each level of the LEP (case farm) and group them to the degree of information obtained from completing the process of addressing each driver for advancing SNM – Freedom to operate, SNM issues and Demonstrated sustainability (reviewed in Chapter 2). At each stage of the analysis, the author was mindful of the subjective nature of the analysis and attempted to maintain autonomy throughout the entire process.

### 3.3.1 Freedom to operate

To establish whether the LEP was an appropriate framework to determine if the farm was operating within the limits of national and regional policy, the information gained throughout the assessment was measured against the requirements of the national and regional rules and guidelines for consent of permitted activities reviewed in Chapter 2. The level of detail required by the Regional Council to grant consent surrounding specific permitted activities (Discharge of contaminants to land etc.) was evaluated and using a strict YES/NO code (reflecting a real life compliant/non-compliant situation) as to whether the information given in each level was enough to satisfy the requirements for the consent and hence, grant the farm freedom to operate (Table 3.5).

***Table 3.5*** *Description of the YES/NO codes used to define the level of information given for determining the farm's freedom to operate for each level of the Land and Environment Planning toolkit*

| Code | Description of code |
|---|---|
| **YES** | The information gained through the process and quantified, described or discussed in the final LEP plan addresses the rule of concern |
| **NO** | The information gained through the process and or in the final plan is not of enough detail to satisfy the requirements of the Regional Council or rule |

### 3.3.2 Nutrient use efficiency

For the information gained to address SNM, the issues were split up into the individual nutrients and evaluated at each Level (1, 2 and 3) of the LEP Toolkit. Each nutrient issue at each level of the kit was given a rating of 0-6 (Table 3.6) to reflect how useful the approach was in terms of the quality and quantity of the information collected through the process set out for each level in addressing water quality and consequent impacts on nutrient management. Comments were also added when necessary, on how useful the levels are and how easy they were for farmers to use. A comparison of levels was also included in the analysis.

***Table 3.6*** *Description of the codes used to define the level of information given for addressing soil and nutrient management issues for each level of the Land and Environment Planning toolkit*

| Code | Description of code | Examples of information detail |
|---|---|---|
| **0** | No knowledge gained | |
| **1** | Minimal knowledge gained | |
| **2** | Understand the possibility that there is an issue but don't understand the mechanisms or processes | High cow SU can lead to N leaching |
| **3** | They understand some of the requirements for the process to occur and can state whether or not they think the process is occurring (i.e. a loss) but not quantify the process | How much of a loss is occurring (low or high) |
| **4** | Able to quantify nutrient loss but not understand the mechanisms | OVERSEER$^{TM}$ output |
| **5** | Able to develop mitigation/management plans (understand nutrient loss processes etc.) | |
| **6** | On farm nutrient loss measurements: Environmental monitoring | Horizons monitoring data site |

### 3.3.3 Ability to demonstrate sustainability

To determine whether the LEP was an appropriate framework to demonstrate sustainability on an international scale, the LEP toolkit and the information gained throughout the assessment was compared against a set list of criteria associated with environmental management systems (EMS). These criteria had to be assembled as part of the study and adapted from guidelines for an EMS as described in Carruthers (2011). Using a 'tick' code each level of the LEP was compared in a table against the individual requirements and assessed as to whether the standard was present or absent in the framework (Table 3.7). If the standard was addressed, the corresponding level was marked with a tick mark ( ✓). If the standard was not present or could not accurately be determined, the box was left blank.

***Table 3.7*** *Description of the tick code used to define the level of information given for determining the farm's ability to demonstrate sustainability for each level of the Land and Environment Planning toolkit*

| Code | Description of code |
|---|---|
| ✓ | The information gained through the process is able to determine whether the level meets the criteria for an EMS |
| | The information gained through the process level does not meet the criteria for an EMS |

# 4. Land and environment planning workshops

## 4.1 Description

Beef + Lamb NZ held two LEP workshops, one in Wanganui on the 16th and the other in Marton on the 21st August 2012. The workshops were held to introduce eight local farmers to the toolkit and to provide advice and guidance from both field experts and industry members (land managers, fertiliser representatives, and Beef + Lamb NZ representatives) on first interrogating and then preparing a LEP toolkit. The workshop methodology allowed room for the farmers to reflect upon each other's contribution, and compare them to their own ideas, adding additional ideas to fill-in the gaps that become apparent in their knowledge (Parminter, 2011). The workshops were included in this research to supplement and reinforce the information gathered through the case farm.

## 4.2 Data collection

After each workshop session had concluded, an unstructured interview was conducted with one of the farmers and also with the land resource expert that had run the workshop. The purpose of the farmer's interview was to assess how they saw the LEP toolkit and to test their understanding of the toolkit and its application to their own farm, and how the workshop had helped their overall understanding of the process and the drivers for advancing SNM. The purpose for the land manager was to see how they felt the LEP toolkit fitted in with the business of farm planning and the ability to achieve the industry's sustainable objectives.

## 4.3 Analysis

The interview transcripts and observation notes were tabulated and analysed to identify the major themes from the interviewees experience with the LEP toolkit. Once identified, the themes were used to organise the results of each level of the LEP (case farm) and group them to the degree of information obtained from completing the process about addressing each driver for advancing SNM.

# Chapter Four Findings

This chapter presents the findings obtained from the case study (Section 3, Chapter 3) and the subsequent analysis of the information collected as each level of the land and environment toolkit (LEP) was completed, and then evaluated against the three key drivers for advancing Soil Nutrient Management (SNM) which were assessed as part of this study.

## 1. Case study farm interviews

### 1.1 Level 1 Evaluation

Both Level 1 evaluations with the farm manager and supervisor were assessed through a desktop study and interviews with the farm manager and supervisor.

**Option 1a: Farm mapping method**

The farm was mapped first in a desktop exercise to explore current environmental concerns and then examined again in regard to potential future concerns. The farm was also assessed for current production classes, where it is not performing to its optimum as part of the identification of future growth opportunities.

Key environmental issues identified during the desktop exercise, included the main stream running through the property and land alongside the Rangitikei River. These waterways are largely unfenced and are used for stock grazing (Figure 4.1).Areas of land susceptible to wind erosion, particularly during cultivation, was another issue identified that requires more attention as the farm moves to more cropping and pasture renewal. Also highlighted in part, was the low number of shelter belts to protect the livestock from wind and rain, and for the provision of shade.

Five main production land units: Easy country, Top country, Medium country, Steep/dry country and Steep country, were identified in the production mapping exercise using the LEP Level 1 mapping approach (Figure 4.1, Table 4.1).

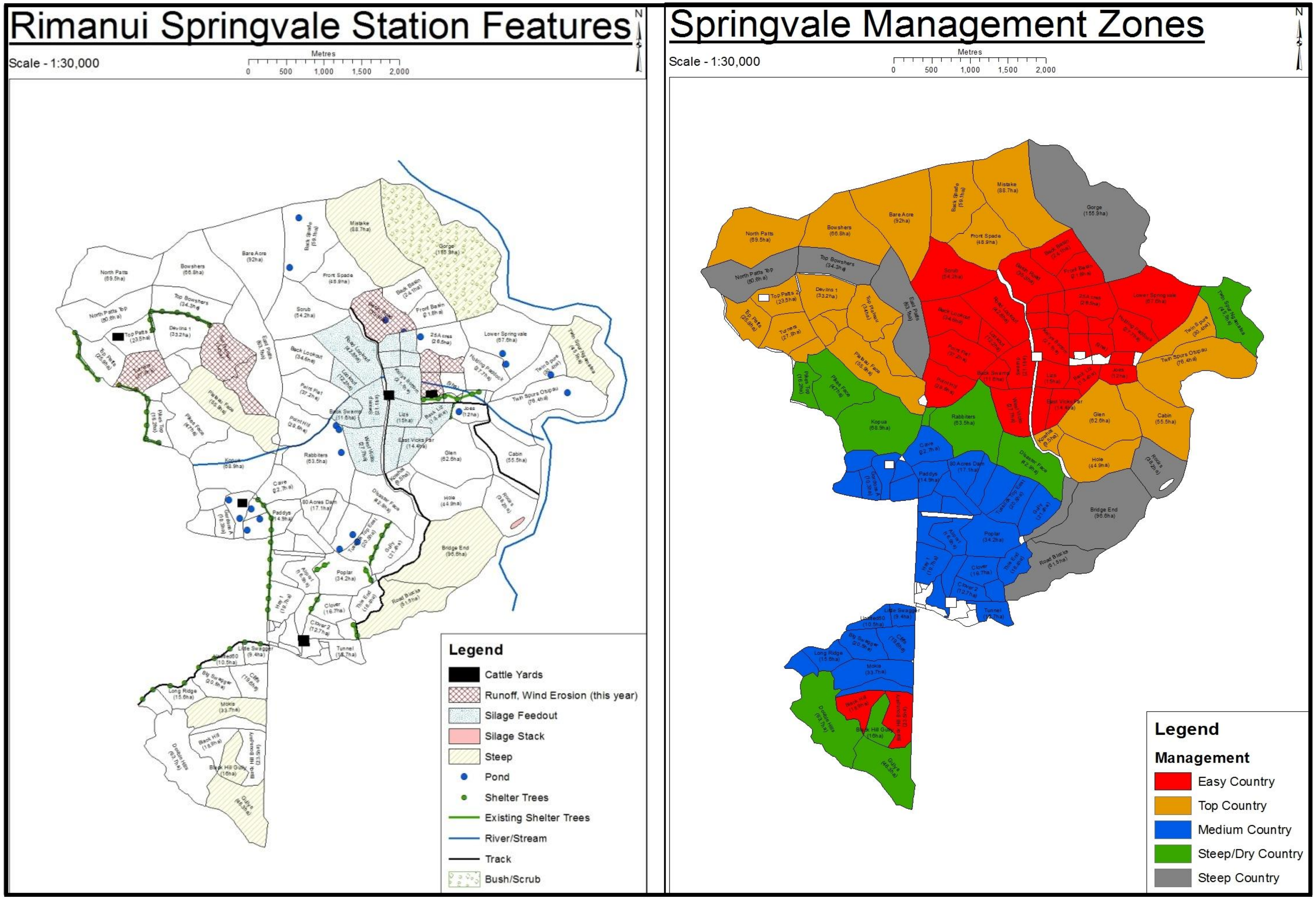


***Figure 4.1*** *Land and Environment Planning toolkit - Level 1a: Springvale Station's perceived environmental issues and main production land units.*

**Table 4.1** A description of the key attributes and typical land use for each production unit on Springvale Station.

| Production land unit | Description | Land use |
|---|---|---|
| **Easy country (red)** | Fertile, high producing soils is located on rolling flats in the middle part of the farm in the bottom of valleys | -fattening/finishing country<br>-cultivation/cropping |
| **Top country (orange)** | Similar to the easy country except for the difference in altitude and so is grazed during different times of the year | -fattening/finishing country<br>-cultivation/cropping |
| **Medium country (blue)** | Moderate fertile soils located on the warmer northerly/westerly facing slopes | -twin grazing country |
| **Steep/dry country (green)** | Located on slopes by the river, the gorge and on the western part of the farm on the easterly facing slopes | -twin grazing country<br>-grazing cattle |
| **Steep country (grey)** | Wet and heavy soils, located throughout the farm on the colder southerly facing hill slopes | -single grazing country |

**Option 1b: Risk assessment method**

**(1) Water quality: Nitrogen**

Based upon the responses to the questions, the Level 1 LEP indicates that the farm holds the potential to have elevated levels of N lost (Figure 4.2). This is indicated by three of the responses:

- Cattle make up more than 20% of the total stock units
- Supplements are brought onto the farm, and N fertiliser is used on farm

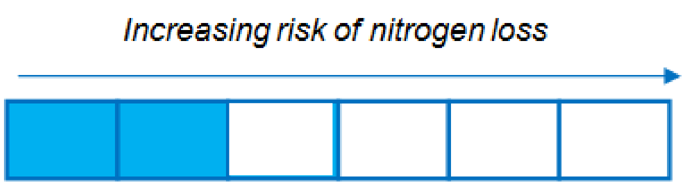


***Figure 4.2*** *Assessment of Springvale farms Nitrogen loss risk - Land and Environment Planning toolkit - Level 1b Water quality.*

**Water quality: Phosphate + faecal bacteria**

Based upon the responses to the risk questions, the Level 1 LEP indicates that the farm holds the potential to have elevated levels of P and faecal bacteria lost to waterways (Figure 4.3). This is indicated by five of the responses:

- Livestock have access to streams and rivers
- Cattle make up more than 20% of the total stock units
- Olsen-P levels are above optimum on approximately 35% of the farm
- Conventional cultivation and/or intense strip grazing is practiced
- More than 50% of the farm is classified as rolling, hilly or steep land

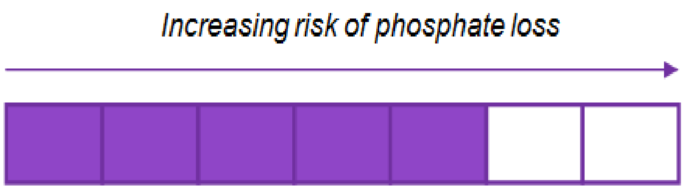


***Figure 4.3*** *Assessment of Springvale farms phosphorus and faecal bacteria loss risk to water - Land and Environment Planning toolkit - Level 1b Water quality.*

### (2) Productive capability

Based upon the responses to the questions, the Level 1 LEP indicates that the farm has areas that are not performing to their optimum productivity (Figure 4.4). This is indicated by three of the responses:

- Current nutrient soil levels for P, K, S, Mg are below optimum
- Significant cattle numbers are grazed on wet soils
- Intensive grazing practiced when the soils are wet
- Invasive weeds present on less than 5% of the farm but are concentrated around issues with accessibility at certain locations e.g. access ways, gates, tracks and runs

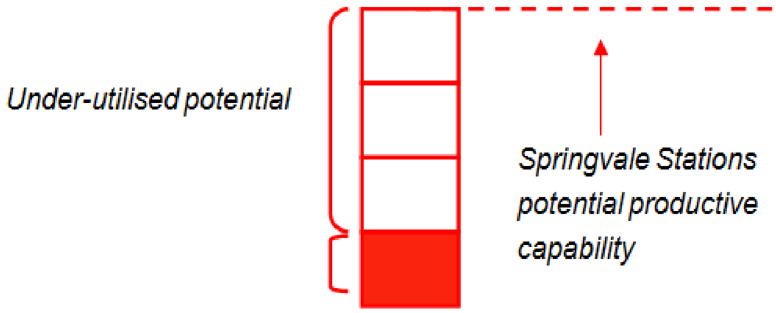


***Figure 4.4*** *Assessment of Springvale farms un-realized potential productive capability - Land and Environment Planning toolkit - Level 1b Productive Capability.*

### (3) Erosion

To determine the farm erosion risk, an assessment is made of how well the farm practices are protecting the soil's natural capital stocks. Based on the current condition of the farm, the Level 1 LEP indicates that the erosion risk to the farm is negligible to slight (wind erosion - Figure 4.1). Both the farm manager and the supervisor stated that the land in the area was not susceptible to erosion, due to the infrequency of intense storm events in the region, although they did indicate that several farming practices (cultivation) had the potential to increase the risk of erosion beyond its natural rate.

### (4) Other issues

Additional environmental and production-based issues of concern not yet addressed were similar for both the farm manager and the supervisor. The Rangitikei River was highlighted as the area of most concern on the farm, followed by the lack of riparian planting along the rivers and wetlands and the presence of a silage stack on the river gravels which was used as feedlot during the winter months, were major concerns.

Cultivation of steeper slopes (>28°) was highlighted as being a potential issue in the future with erosion. The amount of shelter present on farm, in addition to the effect of the neighbouring deer farm on the health of the flock i.e. Tuberculosis (TB) was also highlighted as a low level concern.

**Response plan**

After completion of Level 1 (1a and 1b) of the toolkit, a response plan (Table 4.2) was designed for the main issues identified including:

- Potential elevated risk of N leaching
- High potential for P runoff risk in some areas highlighting the requirement for fencing of waterways
- Overall erosion risk on farm negligible-slight
- High indication that areas of the farm are not performing to their optimum productivity
- Little evidence of riparian management
- Livestock access in waterways
- The amount of shade and shelter on the farm

***Table 4.2*** *Springvale Station's response plan designed after completion of Level 1 of the Land and Environment Planning toolkit.*

| SNM issue | Response |
|---|---|
| **Nitrate leaching** | -Closer look at N required |
| **High phosphate soil levels and potential phosphate loss** | -Fence off waterways<br>-Reduce P fertiliser input on high Olsen P blocks |
| **Low performance** | -Manage nutrients so P, K, S, Mg deficiencies are addressed<br>-Restrict winter grazing on wet and pugging prone paddocks<br>-Manage invasive weeds |
| **Riparian management** | -Fence off main waterway (Rangitikei River) immediately, and work towards fencing off the other over the next year to restrict livestock access |

## 1.2 Level 2 Evaluation

Level 2 of the LEP Toolkit provided the opportunity for a more in-depth analysis of the farm and its resources. Again as a desktop study, the interview was conducted indoors with both the farm manager and supervisor. The Level 2 assessment was completed using the information gained during the Level 1 assessment, along with the identification and selection of the different land management units (LMU) present on the farm.

**Steps 1 and 2 - Prepare property and map land resources**

Using the maps generated in Level 1, the same farm paddock map and relevant farm features (waterways, shelterbelts etc.) was used to map the farms basic resources (Figure 4.1). Primary landforms, (hills, wetlands, flats, and included variations) along with other physical differences (slope, elevation and aspect), were used to split the farm into landforms and into further subdivisions called land type. The landforms were then further subdivided into land types based upon the differences in properties of the land.

**Step 3 – Land management units**

**a) Identification and design of land management units**

The differences on the Springvale farm were largely based upon physical properties such as soil texture and type, drainage, differences in pasture production, aspect, elevation and workability (ability to plough). Through these differences in land resources and subsequent land use, the different land management units present on the farm were identified.

**b) Evaluation of LMU and Resource chart**

Once identified, the LMU were analysed to determine the strengths and weaknesses each land management unit presented and once finalised, recorded in a resource management chart (Table 4.4)

**Step 4 - Nutrient budget**

Using the information provided the OVERSEER™ nutrient budget (Version 6.0) (Figure 4.5) predicted that inputs of N both from fertiliser (10 kg N ha/yr) and atmospheric/clover N (64 kg N ha/yr) resulted in approximately 8 kg N ha/yr lost through leaching processes to water and 31 kg N ha/yr through immobilisation within the soil. Phosphate is predicted to accumulate at a rate of 11 kg P ha/yr through absorption resulting in an estimated decrease of 2 Olsen P unit a year. The model predicts that no magnesium (Mg) input will result in 23 kg Mg ha/yr being lost through leaching processes and a decline in soil magnesium of approximately 3 units per year.

| | N | P | K | S | Ca | Mg | Na |
|---|---|---|---|---|---|---|---|
| | | | | (kg/ha/yr) | | | |
| Nutrients added | | | | | | | |
| Fertiliser, lime & other | 10 | 15 | 1 | 11 | 20 | 0 | 0 |
| Rain/clover N fixation | 64 | 0 | 1 | 2 | 1 | 2 | 5 |
| Irrigation | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Supplements imported | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nutrients removed | | | | | | | |
| As products | 23 | 3 | 12 | 4 | 11 | 1 | 2 |
| Exported effluent | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| As supplements | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| To atmospheric | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| To water | 8 | 0.1 | 12 | 12 | 49 | 23 | 45 |
| Change in internal pools | | | | | | | |
| Plant material | -4 | 0 | -6 | 0 | -1 | 0 | 0 |
| Organic pool | 31 | 3 | 1 | -3 | 0 | 0 | 0 |
| Inorganic mineral | 0 | 11 | -12 | 0 | -2 | -2 | -8 |
| Inorganic soil pool | 1 | -2 | -6 | 0 | -37 | -21 | -33 |

***Figure 4.5*** *Whole farm overseer nutrient budget for Springvale Station (OVERSEER™ 6.0).*

The 8 kg of N lost via leaching processes is within the range found on Sheep and Beef farm systems, but is low, when compared to arable cropping or dairy land uses and is below Horizons Regional Council's N loss limits in year 1 and 5 in the OnePlan for farms converting to an intensive land use predominantly on class VI and VII land. The calculated N loss limit would be at 10.2 kg N ha$^{-1}$ yr$^{-1}$ for the current stocking rate (Table 4.3).

***Table 4.3*** *Cumulative N leaching maximum by Land Use Capability (LUC) class for Springvale Station*

| LUC | N loss limit (kg N ha$^{1)}$) | | Area of LUC (ha) | Percentage of farm* (%) | N loss limit (kg N) | |
|---|---|---|---|---|---|---|
| | 1 year | 5 year | | | 1 year | 5 year |
| **Class III** | 22 | 21 | 61.2 | 2 | 1346.4 | 1285.2 |
| **Class IV** | 16 | 16 | 619 | 21 | 9904 | 9904 |
| **Class VI** | 10 | 10 | 1,572.7 | 54 | 15727 | 15727 |
| **Class VII** | 6 | 6 | 740.6 | 26 | 4443.6 | 4443.6 |
| **Class VIII** | 2 | 2 | 94.2 | 3 | 188.4 | 188.4 |
| **Total N loss limit (kg N ha$^{1}$)** | | | | | **10.2** | **10.2** |

***Source:*** *(Table 13-2 proposed OnePlan) (HRC, 2010).*

**Total area of the farm 3,087.7 ha)*

### Step 5 - Yield gap

*a) Estimate whole-farm pasture yield (current)*

The current whole farm pasture yield per hectare was calculated using the equation below.

| Stock units | | Utilisation factor* | | Whole farm yield | | Effective area | | Yield per ha |
|---|---|---|---|---|---|---|---|---|
| 29,857 | **X 550** ÷ | 0.7 (70%) | = | 23,459,071 | ÷ | 2,935 | = | 7,992 |
| *Total SU* | | | | *Kg DM/yr* | | | | *kg* |

This value of 7,992 kg DM ha$^{-1}$ yr$^{-1}$ represented the minimum amount of pasture that the farm must grow per hectare of pasture to sustain the current stocking rate.

*__Table 4.4__ Strength and weakness resource management chart for the land management units on Springvale farm*

| LMU | Description | Strengths | Weaknesses | Land use & management |
|---|---|---|---|---|
| **1. Easy country** | Fertile, high producing soils located on rolling flats in the middle part of the farm and on valley floors | -Location, tractor accessible<br>-Silage stacks<br>-Good soils<br>-Majority of land fenced into manageable paddocks | -Lack of reticulated water<br>- Pasture damage<br>-Exposed<br>- No shade or shelter in basin area<br>-Winter wet and damage from cultivation | -Fattening/finishing country<br>-some cultivation/cropping |
| **2. Early summer country** | Located on the warmer northerly/westerly facing slopes of the farm | Similar to Early summer country plus:<br>-Higher altitude allows the pasture to grow for longer<br>-Temperature is cooler and so gets more rain | Similar to easy country plus:<br>-Less infrastructure<br>-Not as well historically subdivided as Early summer country | -Twin grazing |
| **3. Breeding country** | Fertile, high producing soils located on rolling flats in the middle part of the farm and on valley floors | -Warm north facing aspect of the slopes<br>-Rolling hills, big paddocks<br>-No problem with weeds<br>-Good natural shelter provided by the topography | -Remote<br>-Lack infrastructure and more labour intensive to develop the land<br>-Stock are eating less pasture than what is produced e.g. utilisation problems | -Fattening/finishing country |
| **4. Steep dry country** | Located on the slopes by the river, the gorge and on the western part of the farm on the easterly facing slopes | -Low maintenance<br>-Some good summer country on south facing slopes<br>-Good weaning country | -Below zero temperatures in winter – high potential to lose stock (cattle)<br>-Low natural soil fertility<br>-Problem with toxic weeds – Flaxes and Toots | -Grazing twinners and cattle |
| **5. Steep wet country** | Cold, wet and heavier soils located throughout the farm on southerly facing hill slopes | Similar to Steep dry country | Similar to Steep dry country plus:<br>-Wet soils | -Singles grazing |

**Step 6 – Response plan**

After completion of Level 2 of the LEP a response plan (Table 4.5) was developed for the SNM issues that were identified including:

- Nitrate leaching and immobilisation of N
- Decrease in soil P in certain paddocks
- Phosphate accumulation, pugged soils, risk of P erosion from critical source areas
- Lack of riparian management
- Under-utilisation of pasture, invasive weeds
- Shade and shelter

***Table 4.5*** *Springvale Station's response plan designed after completion of Land and Environment Planning toolkit - Level 2*

| Nutrient affected | Issue | Response |
|---|---|---|
| **Nitrogen** | Nitrate leaching (8kg N/ha) | -Not a concern (Table 4.3) |
| | Nitrate immobilisation (31kg N/ha) | -Reduce N fertiliser input<br>-Improve stock grazing rotation |
| **Phosphate** | Decrease in soil P (-2 units/ year) | -Apply capital P fertiliser to raise Olsen P |
| | Erosion Potential P loss from CSA | -Fence off waterways<br>-Cease P fertiliser input on high Olsen P paddocks (>30) |
| | Wet, pugged soils | -Restrict cattle winter grazing<br>-Graze only sheep |
| **Nitrogen and Phosphate** | Riparian management | -Fence off main waterway (Rangitikei River) immediately, and work towards fencing off the other streams over the next year<br>-Restrict stock access |
| **Other** | Low performance, under utilisation of pasture | -Manage nutrients so P deficiencies are addressed<br>-Improve stock grazing rotation |
| | Weeds | -Manage invasive weeds |
| | Shade and shelter | -Investigate avenues to get funding to plant some trees |
| | Decline in soil magnesium | -Add magnesium enhanced fertiliser |

## 1.3 Level 3 Evaluation

Using the information gathered in Level 1 and 2, Level 3 of the LEP Toolkit was used to take an even more in depth look at the farm and its resources this time with the input from experts e.g. land managers, fertiliser representatives, LUC mapping etc.

**Steps 1 & 2 - Prepare property and locate land and environmental priorities**

Similar to the steps taken in Level 2, an aerial photograph of the farm and a copy of the farm paddock map were used along with a map for the nutrient management blocks for the farm sourced from Ravensdown fertiliser representative for the farm to help map the farm LMU's.

**Step 3 – Map the land resource**

The mapping exercise started with defining the major units by using the paddocks as a rough guideline along with obvious differences in topography and vegetation. Soil profiles roughly for each unit at locations where the units had changed according to topography, slope, vegetation and colour.

The findings for step 4 are located in the WFP produced for Springvale Station found in Appendix 1. A summary of the findings of each of the five steps (Steps 4, 5, 6, 7 and 8) is found below.

**Step 4 - Identification and allocation of the LUC units**

From the Land Resource Inventory (LRI) and LUC mapping, 16 LUC units were identified and described in the WFP (Section 3.2- 3.3); along with the five LRI factors (rock type, soil unit, slope class, erosion type and severity, and vegetation). From the assessment the farm's soil is derived largely from volcanic parent rocks (tephra) with areas close to the Rangitikei from alluvium (floodplain, gravels). The majority of the farm (60%) was located on land with a >20° and classified as rolling, hilly or steep, with some areas (class VIII) > 35°. There was negligible risk of erosion across the majority of the farm. However certain areas (class VIe, VIIe, VIIIe) that had a slight risk of gully, streambank or sheet erosion occurring or had erosion already present. The major vegetation cover of the farm was under pasture (approximately 1,650 ha), with pockets of forestry (15 ha), bush/scrub (120ha) and wetlands (45ha).

**Step 5 - SWOT analysis of each LUC unit**

An assessment of the strengths and weaknesses was carried out for each LUC unit, along with major features of the LRI (Section 3.4). From this analysis there was a large amount (approximately 60%) of the farm located on fertile free-draining soil with an accessible slope and so is able to be used for cultivation. The rest of the farm was a mixture of steep slopes, forestry blocks, wetlands or subject to cooler weather, with the most common limitations being a colder climate and prone to erosion.

**Step 6 – Nutrient budgeting**

The current soil tests, herbage analysis produced for the whole farm indicate that the farm has a range of fertility levels but are generally within the range for optimal pasture production (Olsen P levels 17-23, optimum pH 5.8-6.0). However, according to the soil tests, an application of 16 kg P/ha across the farm is required to maintain the current stocking rate 10.2 SU/ha. The nutrient budget produced for each management block and the whole farm indicates that 8kg N/year is lost through leaching from the whole farm, and Olsen P is decreasing on Plateau and Middle Hills blocks (1 unit /year) (Section 2.3). Potassium and magnesium units are also predicted to decrease, with Middle Hills block expected to decrease the most (<1 unit/year K and <4 unit/year Mg). Future nutrient management suggests that the farmer redefine the management blocks into groups of the LUC units identified that have similar soils, aspects and stock rate (Section 2.5-2.6)

**Step 7 - Estimated of the pastoral yield gap**

The total annual dry matter production is 8,300 kg DM/ha (Step 5 - Level 2), based on a stocking rate of 29,857 stock unit equivalents and 60-70% pasture utilisation. Through altering farm management techniques, further subdivision and strategic N fertiliser applications, the potential yield gain for Springvale Station is estimated to have a potential yield of 8,900 kg DM/ha/yr at 1,700 SU or 0.6 SU/ha (Section 2.7).

**Step 8 – Recommended environmental works and monitoring programme**

Over the next five years, the WFP recommended several changes to the management of the Springvale station (Section 4.0 - 4.9). These included an investment in 5,150m of riparian fencing, a further 1,250m of fencing for the retirement of 137.6ha low productive land and 1,155m for retirement 10.7ha of wetland area, and planting 300 poplar poles and willow trees for erosion management (Table 4.6).

***Table 4.6*** *Environmental works and monitoring programme recommended for the Springvale farm over the next five years.*

| Environmental issue | Area/Location | Recommended works and monitoring programme | Priority |
|---|---|---|---|
| **Retired land** | 137.6ha | -Fence off 1,250 and retire (erosion prone, lower production) land (137.6ha)<br>-Plant 1,000 spaced poplar poles | **2** |
| **Soil erosion (slump)** | LUC VIe3 | -Plant 125 poplar and willow poles over the next 5 years | **1** |
| **Gully erosion** | Gully on farm | -Plant 3,500 poles in affected areas | **2** |
| **Surface erosion** | Hill country | -Maintain vegetation cover through grazing management<br>-Maintain soil fertility | **3** |
| **Soil erosion** | Critical source areas (CSA) | -Fence off waterways<br>-Cease P fertiliser input on high Olsen P paddocks (>30) | **1** |
| **Riparian management (streambank erosion)** | 21.6 ha | -Fence off 5,150 metres Rangitikei River boundary and streambanks with protective fencing<br>-Restrict stock access | **1** |
| **Wetland** | 10.7ha | -Retire, fence off 1,155m and plant up 10.7 ha of wetland area across the farm | **1** |
| **Soil nutrient imbalance** | Most of the farm (all pastoral LUC) | -Monitor and apply fertiliser so P, K, S, Mg deficiencies are addressed<br>-Improve stock grazing rotation | **2** |
| **Over cultivation of flats** | All pastoral LUC units | - Restrict cultivation to occur only at correct soil moisture levels and use minimum tillage techniques | **3** |
| **Soil pugging , wet soils** | All pastoral LUC units | -Restrict cattle winter grazing<br>-Monitor using visual soils assessment as a guide (VSA) | **2** |
| **Weeds** | Main access ways, across farm | -Monitor and manage invasive weeds (thistle and broom) | **3** |
| **Shade and shelter** | Across the farm, hill country | -Soil conservation planting for the next 5 years | **2** |

## 2. Beef + Lamb NZ Workshops

The two workshops were carried out using an open lecture session approach, where questions could be asked at any point to direct the conversation. The session started with each farmer giving a description of their farm and resources and any environmental or production concerns present. Each level of the toolkit was briefly described and one farmer chosen to go through the process. A farmer was chosen whom had very little previous involvement in activities of this type and had acknowledged that they had little understanding of their land resources in relation to land and environmental planning. Some key themes that were noted during the workshop and from the interviews conducted at the end of the August 16th workshop were:

*Workshop observations*

- The farmers that had undergone another land and/or environmental management programme (SUBS or related programmes) were much better informed and knowledgeable of the landscape and their land resources than those who had not participated in any type of environmental programme before.
- Level 1 (1a and 1b) plan was at a level that farmers very quickly lost interest in completing the workbooks.
- The main SNM issue on hill country and steepland farms is the loss of sediment and P to waterways.
- Implementation of Best Management Practices (BMP's) into farm systems that largely have a positive effect on the surrounding environment, plays second place to actions that will raise the overall productivity of the farm system.

*Sheep and Beef Farmer*

- The farmer was aware of two of the three main drivers for advancing SNM: the Regional Council rules for the area and of potential nutrient issues that could be/were present on their farm, but had no real understanding or knowledge of the mechanisms or processes involved, or of the last driver: international environmental standards.
- Since the farmer had already been through another similar programme (SUBS), he was curious to see what else he could do to improve his farming practices to put him in a good position with the up and coming regional rules (OnePlan), and identify any potential production opportunities present on his farm.
- Prior to completing the LEP at the workshop, the farmer had a lot less to say about his farm and land resources, afterwards, the farmer was able to articulate how he might make improvements to the farm business and nutrient management through methods such as subdivision and more efficient pasture management.
- The farmer understood why fencing off waterways is important and is now able to take notice of the issues present and potential areas of risk on their farm (sediment and P runoff, stock in streams etc.).
- The farmer could now understand the farm in a whole new way and in terms of: a) land resources and where production opportunities exist and b) where they are limited (where to focus their energy in terms of development).
- The farmer had started planting riparian and shelterbelt vegetation.

*Land resource expert*

- The necessity for the LEP toolkit stems partly from political motives involving the current focus on the dairy industry and their impact on waterways. Attention is now shifting to hill country and steepland farm systems and the effect the Sheep and Beef sector has on the environment.

- The main issue on hill country and steepland landscapes is the loss of sediment and P into waterways.
- The LEP gives the farmer a chance to look at their farm from a different angle and aims to make improvements; however, the toolkit is not an overnight solution.
- The toolkit has the potential to assist farmers to understand that it is not about absolute numbers but more about trends in terms of environmental performance.
- From observations to date, the LEP Level 3 has not shown any improvement for the farmer in terms of large monetary benefits, but has shown a significant effect on resolving environmental concerns.

## 3. Evaluating against drivers for advancing SNM

The findings of both the case study, along with supporting data from the workshops, were compared against each of the three drivers using the evaluation criteria developed for this study.

### 3.1 Freedom to operate

The analysis for the national and regional rules (Table 4.7) indicated that there was a clear difference between the three levels and their ability to give details in the final plan to satisfy Regional Council requirements for compliance. These differences included:

- The introductory levels of the toolkit (Level 1a and 1b) showed minimal detail e.g. the amount of N fertiliser applied, however, only whether or not it was >150 kg N/ha).
- Level 2 had a little more detail than Level 1, however there were no specifications as to nutrient and/or sediment discharges and whether these discharges would have an impact or not (council compliance).
- The documentation and evaluation of land disturbance (vegetation clearance and cultivation) was also severely lacking detail and only gave specified information with activities operating within riparian zones.
- Level 3 was the plan with the most detail given in relation to the selected rules (Table 4.7), with the information given sufficient to meet the requirements of all of the rules and regulations for each of the Regional Councils investigated.

### 3.2 Nutrient use efficiency

The key trends of nutrient use efficiency highlighted in the analysis (Table 4.8) were the lack of understanding in the toolkit surrounding the following issues:

- There is a lack of understanding involving nutrient cycling within farm systems in Levels 1 and 2 e.g. Mention urine patches and the potential for N leaching but not how or where it can be more of a problem – stock camps, effect of topography.
- There is no consideration for nutrients other than N and P in Level 1 and 2 of the toolkit, and only minimal information given in Level 3.

- There is minimal information surrounding riparian management, and stock access to waterways.
- There is a lack of linking between the landscape units and the potential for SNM issues. Level 3 has a better grasp of this concept with the addition of LUC units but still lacks the linking of information for the farmer/landowner to be able to start identifying things on their own.
- However, there is potential to link the stock class grazed on the land and the various LUC classes according to each LUC classes observed strengths and weaknesses.

***Table 4.7*** *A simple assessment of the three levels in relation to the information gained throughout the process to satisfy as evidence of compliance at both the National and Regional level for a selection of rules and regulations related to soil and nutrient management practices (Yes- meet requirements, No – do not meet requirements).*

| National/ Regional rule | Conditions | YES or NO Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| **Discharge to land (4 rules)** | 1) 150 kg N/ha/yr<br>2) NMP applications >60kg N/ha<br>3) Aerial application (20m away from waterways and 50m from any rare/threatened habitat)<br>4) Evidence BMP are being followed | YES<br>NO<br>NO<br>NO | YES<br>YES<br>YES<br>YES | YES<br>YES<br>YES<br>YES |
| **Discharge to water (1 rule)** | 1) Demonstrate compliance with N loss limit for the farm - 10.2 kg N $ha^{-1}$ $yr^{-1}$ (Table 13.2- OnePlan) | NO | NO | YES |
| **Land disturbance (6 rules)** | 1) Soil disturbed <100$m^2$ or 100$m^3$<br>2) Vegetation cleared <100$m^2$<br>3) Total area cleared <2-5ha on slopes <20°<br>4) Less than <1ha vegetation cleared on slopes >20°<br>5) Erosion/sediment controls are installed-<br>6) Land cultivated on <25° is only on pre-existing slopes, new land > 20° require consent | NO<br>NO<br>NO<br>YES<br>NO<br>NO | NO<br>YES<br>NO<br>YES<br>NO<br>NO | YES<br>YES<br>YES<br>YES<br>YES<br>YES |
| **Riparian zone management (4 rules)** | 1) Evidence of BMP are being followed<br>2) Area exposed < 200$m^2$<br>3) Volume of sediment disturbed <50m (track and road maintenance only)<br>4) Land cultivated within riparian zone is 5-10m from any waterbody and on slopes <15° | NO<br>NO<br>NO<br>NO | YES<br>NO<br>NO<br>YES | YES<br>YES<br>YES<br>YES |

***Table 4.8*** *Assessment of the three levels in relation to addressing soil and nutrient management issues on Springvale Station*

| Soil nutrient management issue | | Level 1 – Risk assessment | Level 1 – mapping | Level 2 | Level 3 |
|---|---|---|---|---|---|
| **Scale** | Spatial awareness of issues | **1 -** Get no feel for the size and scale of the issues | **3 –** Able to identify hotspots, areas of interest, concern and potential, locate waterways which triggered additional information | 3- Able to identify hotspots, areas of interest, concern and potential, locate waterways which triggered additional information (NOTE: dependent on the information available e.g. DEM) | 5 – Able to identify the different areas according to their land use and susceptibility to various issues (LUC classes) |
| **Nitrogen** | N leaching from pasture | 2 – Given information about stocking rates, rainfall, soil type may increase N leaching | 2 – Can identify areas where leaching could occur but not specifics | 4 – Are made aware of the effect drainage, soil properties have on 2leaching, and OVERSEER™ output but have no real understanding of the processes | 5 – Able to identify as where leaching could occur and quantify how much on a block by block basis |
| | N leaching from crops | 1 – Mention cropping, and the effect of different cultivation methods | 2 - Can identify areas where leaching could occur but not specifics | 4- Able to highlight areas but have no separate quantification of leaching under crop land | 5– Able to identify as where leaching could occur and quantify how much on a block by block basis |
| | Stock transfer | 1 – Mention urine patches, stock camps but not how or why it is influenced by topography | 1 – Can identify differences in topography/paddock names but not specifics | 2 - Mention urine patches, stock camps and can identify differences in topography/paddock names but not specifics | 5– Able to identify stock camps,-urine patches more often occur due to topography and understand the effect of land use on a block by block basis |
| | Riparian zone management | 1 – Mention that animal effluent should not enter waterways but not why it is important to not occur | 2 – Able to identify areas that are unfenced, and mention that animal effluent should not enter waterways but not why | 3 – Able to identify areas where N is a problem and attempt to manage it but have no indication of whether/or how much N is lost via this process | 5 - Able to identify areas where N is a problem, quantify and understand N loss, what are the likely sources of N and develop mitigation strategies |

***Table 4.8** Continued …Assessment of the three levels in relation to addressing soil and nutrient management issues on Springvale Station*

| Soil nutrient management issue | | Level 1 – Risk assessment | Level 1 – mapping | Level 2 | Level 3 |
|---|---|---|---|---|---|
| **Phosphate** | Erosion | 2 – Mention about the risk steeper slopes pose but not how or why it is important | 2 – Able to identify hotspots(e.g. steeper slopes, high Olsen P) and areas at risk to erosion | 3 - Able to identify areas where P erosion is a problem and attempt to identify which erosion processes are responsible and then manage it, have access to an OVERSEER™ output but have no real understanding of the processes involved | 5 - Able to identify areas where P (erosion) is a problem, quantify P loss and understand the different types of erosion, and develop mitigation strategies |
| | Surface runoff | 2 – Mention about the risk steeper slopes pose but not how or why it is important to know | 2 – Able to identify hotspots, areas at risk to surface runoff | 3 - Able to identify hotspots, areas at risk to erosion but only really mentioned when erosion is highlighted as a problem on the farm | 4 - Able to identify hotspots, areas at risk to erosion and quantify loss on a block by block basis |
| | P adsorption/ occlusion | 2 – Mention that different soil types (sandy, volcanic etc.) can have an effect but not how or why it occurs | 0 – No information | 2 - Mention that different soil types (sandy, volcanic) can have an effect but not how or why | 5 - Able to identify as where P can be accumulated and quantify how much on a block by block basis |
| | Animal transfer | 1 – Mention animals stock camps and how that is influenced by topography but not how or why it is important | 1 – Able to identify animal stock camps and how that is influenced by topography but not how or why | 2 - Mention animals stock camps and how that is influenced by topography | 5 - Able to identify as where P is transferred could occur and quantify how much on a block by block basis |

***Table 4.8*** *Continued ..Assessment of the three levels in relation to addressing soil and nutrient management issues on Springvale Station*

| Soil nutrient management issue | | Level 1 – Risk assessment | Level 1 – mapping | Level 2 | Level 3 |
|---|---|---|---|---|---|
| **Riparian zone management** | Stock access to waterways | 1 – Mention that animals should not enter waterways but not why it is important to not occur | 1 - Mention that animals should not enter waterways but not why | 2 - Mention that animals should not enter waterways and that they should be fenced but not how this effects the process of P loss | 3 - Able to identify areas where P is a problem, what are the sources of P and attempt to mitigate the problem |
| **Potassium** | Accumulation | 0 – No information | 0 – No information | 1 – Mentioned but only in terms of soil test results | 4 - Able to identify areas where K accumulation is occurring and quantify loss on a block by block basis |
| **Sulphur** | Leaching | 0 – No information | 0 – No information | 1 – Mentioned but only in terms of soil test results | 4 - Able to identify areas where S leaching is occurring and quantify loss on a block by block basis |
| **Cadmium and fluoride** | Accumulation | 0 – No information | 0 – No information | 0 – No information | 0 – No information |

### 3.3 Demonstrated sustainability

Level 1 (1a and 1b) of the toolkit only met 4/15 of the criteria found in internationally recognised EMS (Table 4.9). Level 2 met 9/15 of the criteria; however the assessment still lacked monitoring and recording aspects, specific targets, features that linked policy with environmental performance and an auditing process. Level 3 met almost all of the criteria (13/15). The conditions that it did not meet were: a certificate issued at the completion of the process and a third party audit of the end product.

***Table 4.9*** *Comparison of Land and Environment Planning toolkit levels against criteria required for an Environmental Management System (EMS) using a simple YES/NO technique: YES ( ✓ ) - meets the criteria, NO (blank) - does not meet the criteria.*

| EMS features | Level 1 – Risk assessment | Level 1 – Mapping | Level 2 | Level 3 – WFP |
|---|---|---|---|---|
| **Voluntary** | ✓ | ✓ | ✓ | ✓ |
| **Ongoing** | | | ✓ | ✓ |
| **Monitoring and recording** | | | | ✓ |
| **Self audited** | | | | ✓ |
| **Self managed** | ✓ | ✓ | ✓ | ✓ |
| **Links policy with environmental performance** | | | | ✓ |
| **Advocates continual improvement** | | | ✓ | ✓ |
| **Identifies risk (severity)** | | | ✓ | ✓ |
| **Sets performance targets** | | | | ✓ |
| **Lists actions** | ✓ | ✓ | ✓ | ✓ |
| **Timeline for actions** | | | ✓ | ✓ |
| **Progress check off (implementation)** | ✓ | ✓ | ✓ | ✓ |
| **Review** | | | ✓ | ✓ |
| **Third party audit** | | | | |
| **Certificate** | | | | |

## 4.4 Summary of LEP Workshop

Key trends noted from both of the workshops interviews were:

- The main SNM issue identified as causing the most concern to both farmers and Regional Authorities on hill country and steepland farms is the loss of sediment and P into waterways
- The LEP toolkit provided farmers with a chance to look at their farm from a whole new angle
- For the farmers who had undergone another type of land/environmental management programme (SUBS or related programmes), they were much more knowledgeable of the landscape and their land resources than those that had not participated in any type of environmental programme before. e.g.

Fencing off waterways and riparian margins to prevent stock access and nutrient loss

- Level 1 evaluation was at a level that farmers very quickly lost interest in completing the exercise
- The toolkit aims to make farmers understand that it is not necessarily about a specific number, but more about trends of nutrient use and efficiency when looking at Regional rules and environmental performance
- For farmers, the fact that by implementing BMP's into the average farm system has a largely positive effect on the surrounding environment still plays second place to actions that will raise the overall productivity of the farm system

# Chapter Five Discussion

## 1. Introduction

The understanding surrounding the utility and rigidity of soil and nutrient management (SNM) tools in New Zealand is still developing. There are many factors that influence the performance of these tools in managing on-farm SNM issues. The aim of this study was to gain insights into the use of a tool available to the Sheep and Beef sector of New Zealand hill country and steepland farm systems, the Land and Environment Planning toolkit (LEP toolkit). To the authors knowledge the toolkit has not been assessed specifically for SNM by the sector or by other agencies including Regional Councils who also have an interest in sustainable nutrient management. With the growing pressure on the primary industry ,to demonstrate responsible use of nutrients and sustainable practices, this study is timely in offering insights into the utility of the tool for addressing not only current and but also potential future SNM issues facing by the sector. This research identified the key factors that influence the utility of this resource management tool, explored the ways in which the LEP toolkit can be used, how effective the toolkit was when compared against the drivers for advancing SNM, and how the toolkit could be changed and/or improved for future use.

In the previous chapter, the LEP toolkit was interrogated and assessed in relation to the capability of each level (1, 2 and 3) to address the three main drivers of advancing SNM; Freedom to operate, Nutrient use efficiency and Demonstrated sustainability. This chapter brings together the information collected and analyzed from that part of the study, and goes on to evaluate the utilisation of the toolkit as a whole.

The first section of this chapter gives an overview of the research findings of the case study and workshops, and examines the strengths and weaknesses of each level when used to address each of the drivers of nutrient management, and includes comments on practical implications. Relevant theory and literature is used to support findings from this research.

The second section explores the potential to change and/or improve the toolkit with an eye for future use. The discussion also provides insights into the utility of the LEP toolkit for advancing sustainable nutrient management in hill and steepland Sheep and Beef farming systems. The implications of this are discussed and involve recommendations for the industry. This section is followed by the limitations of this research which leads to proposals for future research. The chapter concludes with some final thoughts about the study.

## 2. Current status of the Land and Environment Planning toolkit

The first research question aimed to explore the three key drivers identified in the Literature Review (Chapter Two) for advancing SNM in New Zealand Sheep and Beef farm systems:

i) Freedom to operate,
ii) Nutrient use efficiency, and
iii) Demonstrated sustainability.

The ability of Levels 1, 2 and 3 of the LEP toolkit to tackle each of these three drivers is summarised in Figure 5.1 and discussed in the following sections. Each driver was analysed on an individual basis. The following section considers the strengths and weaknesses of each level of the LEP tool kit against each driver separately.

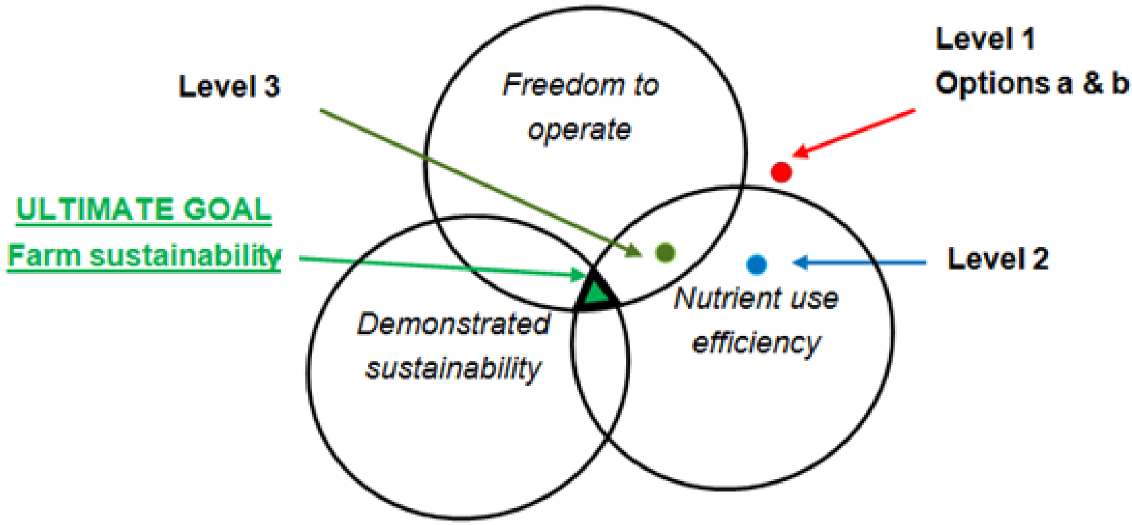


***Figure 5.1*** *Status of the Land and Environment Planning toolkit (levels 1-3) in relation to addressing all the drivers for advancing sustainable nutrient management.*

## 2.1 Freedom to operate

The ability to demonstrate on a regional or national basis that a farm business is operating within their legal requirements is a challenging task. The amount and breadth of information required by Regional Councils is only set to increase as we move into a world where resources are becoming increasingly scarce and there is more of a driver to demonstrate the sustainable use of natural resources. Horizon's Regional Council (HRC) and Waikato Regional Council (WRC) use a mixture of regulatory and non-regulatory education based approaches to manage, and monitor primary industry based activities that can affect SNM. The LEP toolkit, available to Sheep and Beef producers through their levy body (Beef + Lamb NZ), could be used as a tool to affect change in non-regulatory framework and to an extent could also be conceivably used in a regulatory framework.

The introductory levels – Level 1a and 1b farm plan of the LEP Toolkit provided very little information on nutrient inputs or losses in regards to informing Regional or National Council requirements. The only specific piece of information given was the amount of N fertiliser applied, and even then the actual amount was not required if the application >150 kg N/ha (Table 4.7). This enabled farmers to do a quick 'back of the envelope' calculation as to the N leaching status of their farm, and give them a taste of the LEP toolkit and the confidence to move further on to the higher levels (2 and 3). However, due to the quick desktop nature of the exercise, according to regulations for Discharges to Land (Section 13.2) stated in Horizon's OnePlan, this level of information is unsatisfactory and will not provide enough evidence as to whether or not the farm is compliant (HRC, 2010). Level 1 does, however, provide an insight into the implications of issues such as soil erosion, effects of vegetation clearing and intensive livestock activities on the environment.

Level 2 of the toolkit produces a farm plan that has more detail in terms of land resources, including soils and land management units than the introductory levels. However, in the final farm plan required as part of the Level 2 evaluation, there were no specifications as to nutrient discharges or any indication as to whether these discharges would have an impact on the environment. The Regional Councils (both HRC and WRC) required more detailed information regarding activities involving land disturbance (vegetation clearance and cultivation) e.g. the amount of land cleared, area disturbed, slope and location of the activity (HRC, 2010; WRC, 2007). These pieces of information were alluded to, but not able to be extracted from the Level 2 analyses.

Level 3 of the LEP toolkit produced a comprehensive farm plan that provided all the nutrient related information necessary for fertiliser requirements and nutrient budgeting using OVERSEER$^{TM}$ (6.0). The nutrient related information was adequate to meet the requirements for all of the rules and regulations for both Regional Councils investigated (Table 4.7). These rules cover land use activities mainly around vegetation clearance (highly erodible land), nutrient discharges (N leaching limits in sensitive catchments), and cultivation (building tracks, fodder crops, riparian zones etc.). As the majority of these activities are central to running a farming business, the ability to demonstrate compliance to the Regional Council is critical. At present the regulatory requirements are largely based around the nutrient N only with restrictions placed on the amount applied (150-200kg N ha yr), and losses from intensive agricultural practices (OnePlan- LUC N leaching limits). Concern regarding other nutrients, specifically P, are largely governed and monitored by the activities around vegetation management and cultivation practices that can generate the loss of sediment e.g. cultivation and or vegetation clearance on steep slopes (>20°) can result in erosion and sediment loss and hence phosphate loss and transfer to surface waters (McDowell et al., 2004; Parfitt et al., 2008b).

## 2.2 Nutrient use efficiency

Nutrient use efficiency and SNM issues on hill country and steepland farm systems are becoming a prominent and ever increasing issue. In general, there is a lack of understanding by the industry and by farmers of the inputs, outputs, cycling and behaviour of nutrients within these landscapes that is reflected by the differing levels of understanding in the LEP toolkit (Figure 5.2).

The introductory Levels (1a and 1b) of the toolkit proved useful in identifying the environmental and nutrient associated issues on the farm and possible factors that could be contributing to the risk of off-farm losses. These included areas susceptible to wind erosion and surface runoff in some of the paddocks (Top Plateau and Basin Road blocks), intensive winter livestock practices, riparian management issues with unfenced streams and livestock access to the Rangitikei River (Figure 4.1). However, in 1a –Risk assessment there was no method available for quantifying the size and scale of the present or potential issues. As a consequence, it was hard to impress upon the farmer the importance of management of the nutrient issues at this level of investigation. In both Level 1 assessments, there is a list of possible actions that farmers could take in addressing any issues found through the investigation. Again establishing how far to go in advising management changes was difficult. In addition to this, it was difficult to provide individual responses or tailored solutions which made it harder for the farm manager to engage and see the relevance to their farm situation. Therefore, the link between the nutrient issues whether it was environmental or production based, was hard to establish through the amount and type of information given in Level 1.

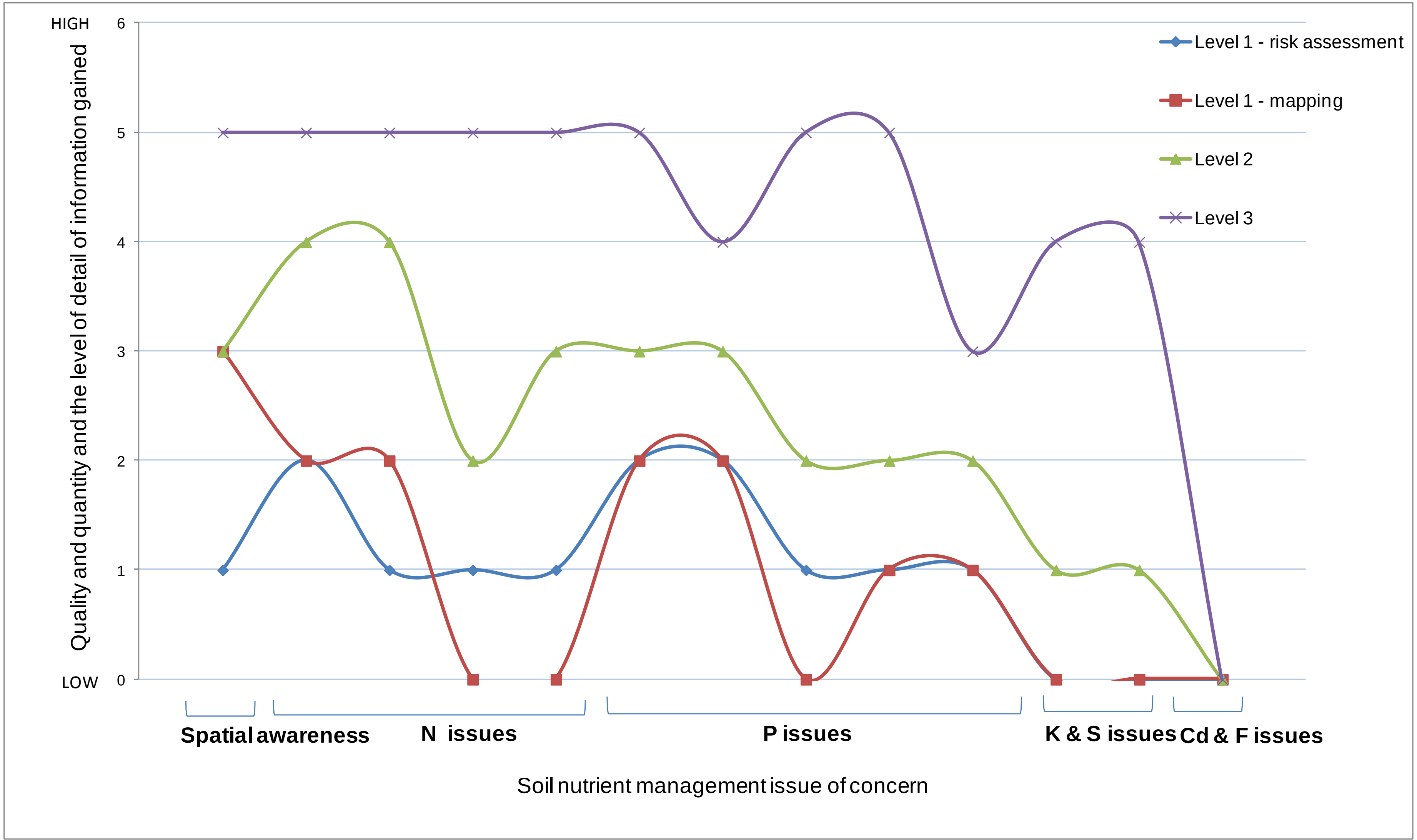


***Figure 5.2** Differences observed between level 1, 2 and 3 of the LEP toolkit in their ability to address nutrient use efficiency issues for hill country and steepland farm systems. (The scale 0-6 and sequence of issues are based upon the order of issues in Table 4.8).*

Level 2 of the toolkit starts to identify production opportunities such as additional land that is suitable for forage crops, as well as environmental challenges (erosion and critical source areas (CSA) for P and N loss) with minimal outside input (Table 4.4). Breaking up the landscape and identifying land management units helped the farmers' understanding of the individual landscape resources present on their farm. Nutrient issues, particularly P and N, are highlighted more through the Level 2 evaluation (erosion and sediment loss, and critical sources areas) and given a list similar to Level 1, with respect to potential mitigating options for managing any problem. A total of between 80 -100 ha of land (3-3.7% of total farm) is either in crops or being prepared for cultivation for crops at any one time. In terms of total on-farm production, the amount of cropping was not a significant enterprise. However, in terms of the impact cultivation and cropping could have on the environment, it becomes a significant source of nutrients and as a consequence, must be managed. This was not taken into account in the Level 2 analysis when evaluating the farm resources and potential for SNM issues. There was also a preliminary nutrient budgeting exercise undertaken that gave some indication of the whole farms nutrient loss for the main nutrients N, P, K and S (Figure 4.6), without pointing to any specific farm practice or land management unit. It was not possible to interrogate in any substantive way to establish what opportunity existed for increasing nutrient use efficiency and reducing the risk of nutrient losses. Hence, there was no way of indicating the urgency required of any response or how it would affect the farm system.

Level 3 proved more useful in advancing SNM through the use of nutrient budgets and nutrient management plans, Level 3 provided the most utility for addressing all the SNM issues of concern for nutrient use efficiency (Figure 5.1). There remained areas where Level 3 lacked targeted information on SNM issues such as management of nitrate leaching around the feed pad on the River Country Block, and around P lost in surface runoff, the identification and mitigation of P loss in the riparian zone, S leaching and Cd and F contamination and management (Table 4.8).

### 2.3 Demonstrated sustainability

The ability of Levels 1 and 2 to demonstrate sustainability at an international level was severely lacking with Level 1 and Level 2 achieving 4/15 and 9/15 of the required criteria. Level 3 on the other hand, was the closest to meeting this aim and in comparison to other EMS schemes in New Zealand and beyond was just short of meeting the criteria (13/15) for the international EMS requirements (Table 5.1). This is in accordance with Paterson and Dewes (2011) review of the LEP toolkit as a credible framework for an internationally recognised environmental management system (EMS). However, the main feature that detracts from the Level 3 evaluation is although it has an auditing guideline, a third party audit is not required and so, Level 3 does not make the final standard for an internationally accredited EMS (refer Table 4.9).

***Table 5.1*** *A list of the audit status of Environmental Management systems available to hill-country sheep and beef farmers.*

| Location | Programme | Audit status | Description | Source |
|---|---|---|---|---|
| **New Zealand** | *Land and Environment Planning toolkit* | | *- Level 3 provides an auditing guideline but is not enforced* | *(Beef + Lamb NZ, 2012; Meat & Wool, 2008)* |
| | The NZ Deer Farmers' Landcare Manual | | -Includes a Quality Assurance -Programme (QAP) but no accreditation | (Paterson et al., 2009) |
| | DairyNZ Clean Streams Accord | X | - Sets out performance targets for the Fonterra suppliers to meet in order to comply.<br>-Third party audit required | (Fonterra, 2003) |
| **Australia** | Beef EMS | | Based on ISO-14001 standard but not adhered to the standards | (Banny, 2003) |
| | Australian Landcare Management System (ALMS) | X | ISO-14001 compliant | (Gleeson & Turner, 2002) |
| **USA** | Michigan Farm *A*SysT – key to environmental stewardship | | -Used to verify compliance with Michigan Agriculture Environmental Assurance Programme<br>-Based on ISO -14001 but not adhered to the standards | (Farrell et al., 2005) |
| **UK** | Linking Environment and Farming (LEAF) | X | -Requires an audit for farmers to gain 'LEAF Marque' certification<br>-Focuses on the audit process required by European supermarkets | (LEAF, 2103) |

## 3. Workshops

The Beef and Lamb workshops provided an opportunity to explore with more farmers, who had a range of previous experiences in collecting and analysing resource information, the utility of the LEP toolkit.

Key trends observed from the interviews and the workshops indicated that farmers that had been exposed to other educational programmes (land or environmental management based), were in a much better position to communicate and have more educated conversations about their farm and land resources with the land managers present at the workshop. This showed that regardless of the level of education (LEP Level 1, 2, or 3), that any interaction with the programme can benefit the farmer's understanding and hence, their ability to engage in the process and progress towards more sustainable business practices (Waugh, 2011). A number of the farmers and the facilitators running the workshop found little value in Level 1 of the toolkit. This may be due to the fact that 5 of the 8 farmers present already had been through some type of a land/environmental management programme, and as a consequence had a good awareness of the link between resources and production and the major underlying resource issues facing their farming operation. The supervisor and the farm manager from Springvale Station would sit in the camp of the producers with a good understanding of the farm resources in relation to the farm production goals and the environment, but gained value in the use of the toolkit in prioritising the environmental issues and developing a response.

The main SNM issue identified by the farmers in the workshops and of most concern to the farmers in these landscapes was erosion and sediment loss, and the resulting loss of P into surface waters. There was considerable discussion on the specific nutrient targets for example proposed regulations (e.g. OnePlan – N leaching limits). The toolkit's aims were to assist farmers in building an understanding that is not about absolute numbers but more about trends in environmental performance.

The most interesting of trends that was observed however, was the fact that the reason that farmers were attending the workshop was not wholly driven by regulations and environmental obligation, but also an avenue to identify production opportunities present on their farms. This indicated that the farmer was aware that improved environmental performance can lead to improved nutrient use efficiency and opportunities to increase their production, especially when such programmes e.g. WFP, are somewhat subsidised (Botha & Roth, 2011).

## 4. Utilisation of the LEP toolkit

The utility of the LEP toolkit to a farmer will ultimately depend on what they want to get out of completing the toolkit, i.e. what their end goal is. Ideally the end goal for all stakeholders involved (Regional Councils, farmers, Industry sectors) is for the land owners to achieve 'farm sustainability'. Defining what that might mean or include needs to consider a multitude of elements including proving land use compliance to Regional Councils and the community, addressing minor or major SNM issues present on the farm, identifying potential production opportunities, or obtaining premiums for their products by demonstrating to customers and the market, that the business is operating in an environmentally responsible and sustainable manner. These drivers/issues need to be questions asked by both farmers and land managers when looking to the future and to the utility of the LEP toolkit.

Studies by Rollins (1993), and King and Rollins (1995), have shown that educational programmes developed by any industry need to cater for the five different types of adopters: the innovators, and early adopters, early majority, then the late majority and lastly, the laggers. When applied to farmers, the innovators and early adaptors are the first farmers that are engaged, attend workshops and meetings and generally have the resources (both financial and intellectual) to buy-into such programmes. The early majority are slower on the uptake than the first farmers. The later majority are more sceptical and cautious in their approach and do not buy in until most of the other farmers in their region have done so. The last group, the laggers, are the traditional farmers who make their decisions largely based on past experience and are suspicious of new ideas. It takes a long time for these farmers to adopt a new idea/programme (Journeaux, 2009). Therefore any programme developed that wants to achieve environmental outcomes needs to address the approaches of the five different types of farmer adoption to achieve full engagement.

The LEP toolkit is unique in its approach, in that it has three levels that build upon the knowledge gained through the completion of each level, which is in line with Rollins theory of the different types of adopters. However, through this investigation, questions have been raised as to the utility of the levels and whether there is room for further growth. From the research findings it is apparent that Level 1 of the toolkit (both 1a and 1b), was at a level that farmers very quickly lost interest in completing. On the other hand, the Level 1 exercises were not intimidating to the farmer and did not require any outside input from experts. Hence, the Level 1 exercise could be completed by the farmer without stepping outside the door in a desktop exercise. The Level 1 falls short (Tables 4.7- 4.9) in addressing the three drivers investigated for advancing SNM, this indicates that Level 1 should only be used as an entry point and farmers should progress beyond this point to level 2. Level 1 of the toolkit, however, was useful when introducing environmental issues to a farmer who had not been exposed to other educational programmes (land or environmental management based). Therefore, any level of interaction with an environmentally based programme (LEP Level 1, 2, or 3) is to be encouraged and can only benefit the farmer by increasing their understanding and hence, ability to further engage in the process of advancing sustainable land use (Rollins, 1993; Waugh, 2011).

The findings from this research support the use of the LEP toolkit in a stepwise approach, as its configuration encourages continual improvement. This accommodates very well the five different types of adopters (Rollins, 1993). The literature and this research both find that an environmental programme (LEP toolkit) needs to be simple enough for the lower end of farmers to buy in and not be intimidated, whilst providing a framework for a natural progression of stages for the farmers to continually improve through the completion for each level of the toolkit, as well as a final level that has sufficient rigour to produce a robust defendable package (Waugh, 2011). At present there are some omissions from level 3 of the current LEP toolkit that need to be added to meet the international standard for continually improving (Carruthers, 2011). Furthermore, there is opportunity to further integrate the level 3 into other components of the farm business to ensure the farm's resources are used the most efficiently and at the same time the environment is protected.

## 5. Evaluation of the toolkit

An evaluation of the utility of the toolkit framework, and the main strengths and weaknesses identified for each level, when measured against the three drivers are discussed in the following section.

### 5.1 Level 1

In terms of the utility of the toolkit, the main strengths identified for Level 1 (both Options 1a and 1b) were that first it was a quick and easy exercise that the average farmer could do on their own. Second it was very useful in identifying and providing an insight into the major environmental issues present on the farm (Table .5.1). Alongside these positive aspects to the introductory level, the main weaknesses were that the information produced was not very detailed and the ability to have educated conversations with the land owner about the drivers for advancing SNM, the land resources, and future production opportunities was limited due to the scope of the exercise. In terms of addressing each of the drivers, Level 1 showed minimal detail (only N) about the nutrient amounts applied or lost from the farm which was insufficient to satisfy Regional Council requirements for compliance. This trend carried on into the nutrient use efficiency driver, where there was a lack of understanding involving nutrient cycling within farm systems. Although it was illustrated that nutrient related problems could occur, there were no strong linkages between how and/or where it is more likely to be a problem at a farm scale. The biggest area where the Level 1 exercises fell short was the ability of the tool to demonstrate sustainability. Level 1 (1a and 1b) of the toolkit only met 4/15 of the criteria that were required to be classed as an internationally recognised standard (ISO 14001).

### 5.2 Level 2

The Level 2 evaluation also proved not to be intimidating to the average farmer. The farm plan produced contained more detail than Level 1 and only required minimal outside input to complete (soil mapping and nutrient budgeting). Similar to Level 1, the information gained from the farm plan still lacked the detail required for demonstrating compliance on a regional level and in turn, fell short of the ability to demonstrate sustainability on an international scale meeting only 9/15 criteria for an EMS.

The Level 2 evaluation, nonetheless, starts to identify production opportunities and environmental challenges present on the farm, and nutrient issues, particularly P (erosion and sediment loss, and critical sources areas) are also highlighted throughout the evaluation (Figure 5.1). However, to maximise the value from a Level 2 evaluation, input would be required from land management experts. As the LEP Level 2 is largely farmer driven, sourcing input from an expert immediately starts by default a Level 3 planning process.

### 5.3 Level 3

The Level 3 evaluation requires the collection of detailed information at the scale of decision making and a comprehensive analysis as part of the review of the farm's resources. In addition to the in depth information gathering and analysis, the Level 3 evaluation also provided the greatest opportunity to interact with the farmer on a one-to-one basis, as the plan is developed. The Level 3 evaluation requires a considerable amount of resources and access to expertise that is of limited availability in some parts of the country. Level 3 takes a considerable amount of the farmers' time and resources to compete if the maximum value is to be extracted from the exercise. There is a risk the farmer might get intimidated and or overwhelmed with the amount of information generated and not obtain the benefits the tool that Level 3 potentially offers.

Farmers that have major SNM opportunities or challenges might wish to advance beyond Level 3 and include additional analysis of the information available before making a decision about a future practice. In these situations the land resource information and the linkages between nutrients and the landscape and production, profit and environment required clipping the Level 3 information to other tools (e.g Farmax). To facilitate these linkages further developments and extensions to the LEP toolkit would be required.

In terms of addressing the three drivers, Level 3 was the most informative. Through the use of accurate nutrient budgets, quantified nutrient losses are able to be determined and a trend of nutrient loss established for the whole farm as well as for each of the nine nutrient management blocks. This allowed the Level 3 WFP to satisfy Regional Council requirements for compliance. In addition to this, the farm plan was able to identify a range of SNM issues at various scales (e.g. erosion on Plateau Block, and nutrient leaching from the feed pad located on river gravels), and identify areas where production opportunities existed (flat blocks - intensive beef grazing). In terms of requirements to be classified as an internationally recognised standard, the Level 3 was the closest of the toolkit's levels (13/15 criteria), and only requires an enforced third party audit and a certificate issued to become compliant with international standards.

***Table 5.2*** *Strengths and weaknesses of the Land Environment Planning toolkit at a technical and practical level against the three main drivers.*

| LEP level | Strengths | Weaknesses |
|---|---|---|
| ***Level 1 a - Farm mapping method*** | -Quick<br>-Straightforward to use (no outside input required)<br>-Self managed<br>-Can identify and spatially reference SNM issues<br>-Most major issues identified<br>- Not intimidating<br>-Uses the farmer's knowledge of the resources – generational knowledge<br>-Results in a response plan with a list of actions and progress check off list | -Easy to miss things<br>-Lack of soil knowledge<br>-No indication of nutrient use/management? (nutrient budgets)<br>-Cannot quantify nutrient loss<br>-Unable to look at specific issues e.g. wintering cattle<br>-Unable to have very sophisticated conversations about the resource<br>-No monitoring or recording procedures |
| ***Level 1 b - Risk assessment method*** | -Quick<br>-Straightforward to use (no outside input required)<br>-Not intimidating<br>-Self managed<br>-Results in a response plan with a list of actions and progress check off list | -Unable to identify and spatially reference the severity/intensity of SNM issues present on farm<br>-Easy to miss things<br>-Lack of soil knowledge<br>-Can't look at specific issues e.g. wintering cattle<br>-No indication of nutrient use/management? (nutrient budgets)<br>-Cannot quantify nutrient loss<br>-Cannot have very sophisticated conversations about the resource<br>-No monitoring or recording procedures |
| ***Level 2*** | -Get a slightly more detailed idea of the issues present (only for N and P) than Level 1 – risk severity<br>-Can quantify some nutrient loss<br>- Results in a response plan with a list of actions and progress check off list<br>-Encourages continual improvement<br>-Largely self-managed<br>- Not as intensive/intimidating as Level 3 | -Requires outside input to get the most out of Level 2 which can be costly to the farmer<br>-Cannot quantify nutrient loss on a detailed scale<br>-Can be intimidating to the farmer to have to complete by themselves<br>-Unable to look at specific issues e.g. wintering cattle<br>-Limited conversations about the resource<br>-No monitoring or recording procedures |

***Table 5.3*** *Continued…Strengths and weaknesses of the Land Environment Planning toolkit at a technical and practical level against the three main drivers*

| LEP level | Strengths | Weaknesses |
|---|---|---|
| ***Level 3*** | -Highly detailed account of the farms resources and present and potential SNM issues<br>-Takes into account various linked issues – and land management priorities<br>- LUC mapping very fast (run on the principle that they get 90% of the mapping right – so not as good as soil mapping but still much better than 1:50,000 -NZLRI mapping)<br>-Results in a response plan with a list of actions, Progress check off list and timeline for actions<br>-Provides a long term benefit scheme (20 year works programme – funding etc.)<br>-Can quantify detailed nutrient loss<br>-Greater interaction with the farmer than other levels (opportunities to educate and inform) | -Takes a long time to complete<br>-Easy to get lost in the details<br>-Problem with consistent mapping is largely subjective/objective<br>-Requires outside input which can be costly to the farmer if not subsidised e.g. WFP<br>- No third party audit required<br>-Somewhat removes the farmer from the process (less ownership of the process)<br>-Intimidating to the farmer<br>- Farmer sometimes overwhelmed with the amount of information given to them |

## 6. Looking to the future

Now that we have analysed the current status of the LEP toolkit, it is time to look at how we can improve the toolkit with the intention to operate in a future environment which might include limits on emissions off-farm. As shown in section 4, there are many strengths of the toolkit at each level that can be built upon. However, there are several gaps and weaknesses within the framework highlighted by this research that need further development. . These include:

1) Ability to meet the criteria for recognised EMS.
2) The lack of understanding around nutrient cycling, and linkages between the landscapes on hill country and steepland farms.
3) Integration of Level 3 into other farm planning tools.
4) Identification of land for future opportunities.

### 6.1 Meeting the criteria

Level 3 WFP framework has one key advantage over other environmentally based programmes - it is designed for industry good. This means that the Sheep and Beef sector has recognised that its' economic success is dependent on demonstrating responsible resource use, and the future of the industry will be measured in part against its environmental performance, especially in the higher end markets. This feature sanctions farmers to have more of a buy-in into the toolkit, and have greater ownership over the management of the environment, with their future livelihood depending on environmental performance as well as production (Manderson, 2009; Paterson, 2011). However, as pointed out in section 4 (Chapter 5), the LEP toolkit has an audit framework set out but does not have an enforced third party audit of the farm plan as part of the process. This is a crucial part of the LEP toolkit that needs to be changed to be able to meet international environmental standards (ISO 14001 standard).

### 6.2 Greater linkages between the landscape and nutrients

The understanding around these nutrient cycles and nutrient linkages within the landscape for farmers and the industry is seriously lacking. Particular areas that need addressing are the critical sources areas (CSA) for nutrient losses e.g. camp sites, urine patches, wetlands etc. The key concept behind nutrient use in New Zealand Sheep and Beef farm systems is the placement of nutrients where they are needed most in the landscape.

As reviewed in Chapter 2, nutrient cycling in hill country and steepland pastures is a complex and interrelated process. One of the single biggest drivers of fertiliser requirements (namely P) each year is the animal transfer factor (ATF) and the redistribution of nutrients within the paddocks (Saggar et al., 1990b). The complexity of these relationships is poorly reflected in the LEP toolkit. Level 3 provides the most detail and information regarding nutrient transfer e.g. identification of stock camps and the influence topography can have on nutrient accumulation (Table 4.8). However, there is little interpretation of the flow on effects this constant transfer of nutrients in the dung and urine down and/or uphill could have on nutrient management such as fertiliser management around access ways or the flatter crests and ridges (Rowarth, 1987). The uneven redistribution creates CSA where P and N loss can occur through surface runoff and erosion, and nitrate leaching, resulting in water quality issues such as eutrophication (Ledgard, 2001; McDowell et al., 2009). This could be more accurately captured with the addition of a Nutrient management Plan to the Level 3 evaluation.

Nutrient accumulation within farm landscapes such as wetlands, riparian margins and peat lands are also causes for concern. This is because these areas, much like CSA derived from animal excretal deposits, cause a concentration or sink of nutrients from which they can be lost through drainage or runoff events (Barling & Moore, 1994; Cooke, 1988). The riparian management in the current LEP needs a lot of attention. There were many challenges presented in the case farm that highlighted the gaps within the LEP, especially in the earlier levels (Levels 1 and 2), where the toolkit completely skipped over nutrient management issues with other nutrients (K and S), and issues leading to contaminant accumulation (Cd and F). These issues need to be further addressed in the LEP toolkit. This can be achieved through the development of the Level 3 part of the toolkit into introducing the idea of the effect of nutrient transfer within the landscape into Levels 1 and 2, and undergo an investigation in Level 3.

### 6.3 Integration of the level 3 into other farm planning tools

Greater integration of the Level 3 with other farm planning tools has the potential to extract greater value from the information collected and analysis as part of the process in developing a Level 3 plan from the tool, but also the opportunity to better integrate resource management into the business planning cycle (Figure 5.3). Linking to other farm planning tools e.g. nutrient budgets and nutrient management plans, FARMAX, market orientated QAP's and whole farm business plans (life cycle assessment) would be the first step in enabling the elements of the Level 3 plans to be incorporated into more of the features (e.g. business and market requirements) of the farming business. An integrated farm planning tool would increase the utility of the toolkit by allowing the SNM issues to be considered alongside all the other drivers influencing the business.

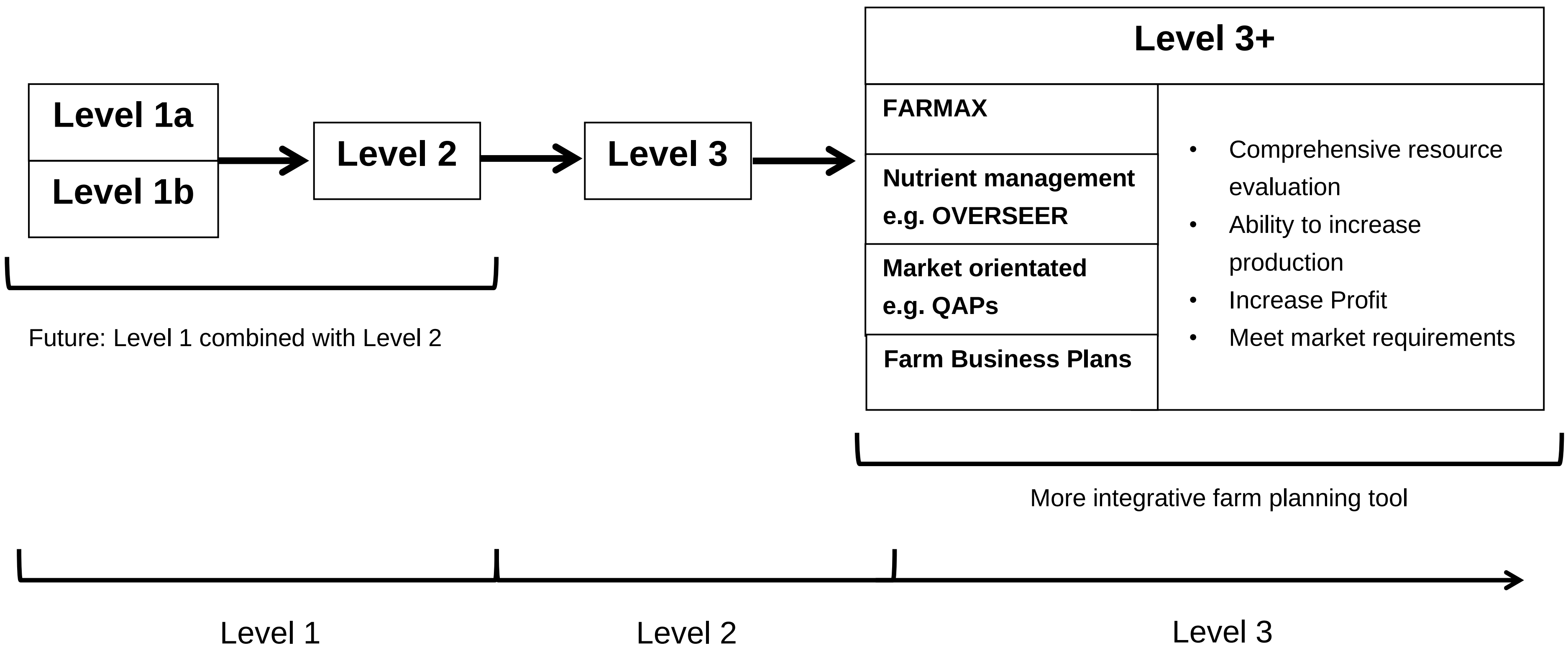


*Figure 5.3 Proposed improvement of the Land and Environment Planning toolkit as a more integrative nutrient management tool.*

## 6.4 Identification of land for future opportunities

There were several opportunities identified through the completion of Level 3 that could be explored further through the LEP toolkit through changes to the current framework. The opportunities identified were mainly based around increasing pasture production and utilisation which is in line with the farmers' ultimate intentions of completing the toolkit as identified in the workshop interviews. Opportunities identified on Springvale Station included:

1. Intensive beef strip grazing

There were several flatter areas located in the middle of the farm on quite versatile land (LUC IVe12 – 340 ha) that if managed appropriately could be used for intensive beef strip grazing. This would be appropriate winter management for the beef stock on the farm.

2. Vulnerable versus versatile land

The main opportunities that exist within the LEP toolkit, and only really at Level 3, are the identification of the vulnerable versus versatile landscape units. The nature of farming is essentially striking a balance between these two mediums. The result that is some land uses are limited on certain parcels of land e.g. cropping on land classes VIw due to potential pugging of wet soils and, VIIe and VIIIe due to risk of erosion. To develop and explore these opportunities or limitations present, however, is not possible under the current framework for the LEP toolkit.

3. Linking stock type to the LUC class of the land

The ability to link the livestock class grazed on the land and LUC class has massive potential on Springvale Station. By placing livestock on the farm according to the land's ability to cope with a number of conditions: stock rate, wetness, fertility, erosion potential etc. would enable an estimate to be made of the sustainable use of the farm's land resources. Importantly the balance of the LUC units across the farm would be a critical element in any analysis in defining the sustainable livestock class ratio. This link could also potentially be the point at which the LEP could feed into Regional Council plans by addressing both the management of the land and achieving environmental outcomes through the completion of a LEP Level 3 or beyond.

The opportunity exists to include more soil information at level 3 particularly on the flat and rolling landscapes where soil properties are more important in determining land use, than on hill and steepland where slope and other factors become important drivers of land use (Manderson & Palmer, 2006). The reliance on the LUC (Level 3) is useful from the farm perspective and will answer most of the farmer queries at a farm level. However, if there is further investigation required, a more comprehensive soil survey undertaken at a smaller scale than the LUC mapping (1:8,000) would be advantageous. Even if it is only on the parcel of land that is under question, reliable soil information is essential to support agricultural decision making. This is in accordance with several studies involving factors influencing agricultural decisions (Manderson & Palmer, 2006; Bouma, 2001; White, 1997).

## 7. Limitations of the research

This study was of an exploratory nature rather than a strict test of variables against a pre-determined relationship. This was due to the fact that little research had been conducted on the LEP toolkit or other such environmental management systems (EMS) applicable to the New Zealand Sheep and Beef sector.

A case study and workshop enabled an exploratory view of a particular situation and aims to understand a particular end user (Springvale Station) experience with a programme (LEP toolkit), in the absence of any published methods for evaluating tools of this type. The approached adopted for assessing the tool kits against the three drivers of SNM offers the basis of a framework for future research.

Data was only collected from one case farm. Against this limitation was the unique fact that the farm employed both a farm manager and a supervisor whom had very different roles and perspectives on the farm, but came to the same conclusions as they were taken through level 1 independently and agreed with the outcomes from the combined exercise completed for level 2.

At each stage of the analysis, the author was mindful of the subjective nature of the analysis and attempted to maintain autonomy through the entire process. However, this analysis is of one very specific situation and carried out in a subjective manner with a lot of the observations reported as narratives and as a consequence, the results were largely interpretive. Other difficulties encountered that influenced the time taken to complete the research were the time required to coordinate several different agencies (Massey University, AgResearch, Horizons Regional Council and Landvision).

## Summary & Conclusions

This study concludes that there are many complex and interrelated factors influencing the advancement of soil and nutrient management (SNM) in New Zealand Sheep and Beef farm systems. The understanding of these factors by both farmers and the industry is crucial to the future success (overall productivity and environmental stability) of the sector. Key points noted throughout the study are summarized below by chapter.

**Chapter One: Introduction**

- Environmental sustainability is of increasing importance to the worldwide agricultural sector. There are many environmental issues including erosion and sediment losses and off site challenges (nutrient enrichment of waterways) facing New Zealand Sheep and Beef farmers on an annual basis. There is also growing concern over the long-term sustainability of this land and surrounding environment, and the need for a comprehensive land management plan to understand the strengths and weaknesses of the land resources, and how management decisions impact on these resources is greater than ever before.
- The aim of this study was to gain insights into the utility of a SNM tool (LEP toolkit) available to the Sheep and Beef sector against the drivers for advancing SNM in New Zealand hill country and steepland farm systems.

**Chapter Two: Literature review**

- In the past the Government and Regional Councils relied on Best Management Practices (BMPs), whereas today Regional Councils are moving towards the use of a combination of regulatory (strongly based on N leaching) and non-regulatory approaches (Whole Farm Plans, Nutrient management Plans) to regulate and control nutrient use. This leads to an effects based regulatory environment that captures the major land use activities that effect the environment (e.g. sediment loss from land disturbance, limits on excessive N fertiliser use, nutrient discharges to land or water), but miss the more subtle land use activities that can over time have a greater affect on the surrounding environment.
- Nutrient use efficiency in hill country and steepland farm systems is more focused on loss of P (sediment loss and erosion, surface run off from critical source areas), and the issue of nutrient transfer (N and P) between the different landscape (topographies) units. This leads to a greater need for understanding of nutrient cycling and for technologies and practices that encourage more accurate placement of required nutrients in the right ratios where they are needed most in the landscape (deficient) and therefore, where they will be most effectively used.
- The ability to demonstrate sustainability on an international level is becoming increasingly more important to the New Zealand Sheep and Beef sector. The key force advancing SNM in hill country and steepland and the development of

a series of codes of practice, initiatives and guidelines has mainly come from industry bodies (Beef + Lamb NZ, fertiliser companies etc.). These approaches are largely based BMPs that aim to reduce the impact (largely focused on nutrient losses) of the Sheep and Beef sector on the environment. Despite this, all of these tools, initiatives and approaches are still lacking in some way when it comes to solidly addressing the drivers for advancing SNM, and the validity and reliability of the programmes in practice is yet to be verified. However, the EMS ISO 14001 was found to be the international standard with the most influence and recognition for environmental performance.

- Current SNM tools available to the Sheep and Beef sector are generally developed for the industry, and driven by industry motives (improve public perception, image etc.). The tools are packaged according to the motive driving the generation of the tool and are generally various combinations of the tools available to the sector, (BMPs, NBs, NMPs, WFPs and QAPs) and nutrient management tool packages.
- The LEP toolkit is one of these SNM tools designed to be a more practical approach for the Sheep and Beef sector to help farmers with their business and resource planning. The toolkit provides Sheep and Beef farmers with a package for building a better understanding of, and developing plans for advancing on-farm nutrient management to ensure efficient use of the fertiliser dollar and limit the impact of nutrient losses to the environment. The toolkit uses a step-by-step guide through a choice of three levels that provide a farm plan that can be tailored for individual farming situations depending on the level of inquiry required. The toolkit has been in use since its release by Beef + Lamb NZ (then Meat & Wool) in 2008, and to date the evaluation of the toolkit has been very limited. To the author's knowledge it has not been critiqued specifically for the effectiveness of using the step-wise approach (Level 1, to 2, and to 3) of the toolkit for the identification of (page 45) SNM issues, or for gathering information for decisions around nutrient management.

**Chapter Three: Research design**

- The design for this research used both quantitative and qualitative methods, including a case study (farm interview) and interactive workshops, to determine the utility of each of the three levels of the LEP toolkit and whether they progressively add the elements, flexibility and rigour necessary to address the current and future drivers that will shape SNM for hill country and steepland farmers. Primary data was collected during the fieldwork and interviews on the case farm, and during the LEP workshop meetings and immediately following through interviews.
- Data was analysed separately for each of the three key drivers identified in the literature review (freedom to operate, nutrient use efficiency and ability to demonstrate sustainability) using a code developed by the author based upon the principles for code development described by Boyatzis (1998). Each level of the toolkit was evaluated against each of the following coding methods:

- Freedom to operate was evaluated using a strict YES/NO code as to whether the information given in each level was enough to satisfy the requirements for resource consent.
- Nutrient use efficiency was given a rating of 0-6 (0 = no information, 6 = of a standard equal to environmental monitoring) to reflect how useful in terms of the quantity and the quality of the information given in the farm plan was for addressing water quality and impacts on nutrient management.
- Ability to demonstrate sustainability was also evaluated against a predetermined list of criteria for an EMS as described in Carruthers (2011). A simple tick mark indicated whether the standard was present or absent in the framework when compared against the EMS standards.

**Chapter Four & Five: Findings and discussion**

**Case study farm and LEP workshop interviews**

- Farmers that have participated in other educational programmes (land or environmental management based), were in a much better position to have more educated conversations about their farm and land resources. The end result of this being that regardless of the level of education (LEP Level 1, 2, or 3), any interaction with a programme can benefit the farmers' understanding and hence, their ability to engage in the process and progress towards more sustainable business practices.
- The reason that farmers were attending the workshop was not wholly driven by looming regulations and environmental obligation, but also an avenue to identify production opportunities on their farms.
- The findings from this research support the use of the LEP toolkit in a stepwise approach, as its configuration encourages continual improvement and links in with the five different types of adopters (Rollins, 1993).
- The literature and this research both find that an environmental programme (LEP toolkit) needs to be simple enough for the lower end of farmers to buy in and not be intimidated, whilst providing a framework for a natural progression of stages for the farmers to continually improve through the completion for each level of the toolkit.

**Level 1**

- In terms of freedom to operate, the introductory levels – Level 1a and 1b farm plan provided an insight into the implications of issues such as soil erosion, vegetation clearing and intensive livestock activities on the environment. However, Level 1 provided minimal detailed information on nutrient inputs or losses in regards to informing Regional or National Council requirements for consent and hence, freedom to operate. The only specific piece of information given was whether the amount of N fertiliser applied was greater or less than 150 kg N/ha.

- The introductory levels also proved useful in identifying the environmental and nutrient associated issues on the farm and possible factors that could be contributing to the risk of off-farm losses. As there was no method available for quantifying the size and scale of the present or potential issue, it was also difficult to provide individual responses or tailored solutions, and hence impress upon the farmer the severity of the issue identified. The link between the nutrient issues whether it be environmental or production based, was hard to establish through the amount and type of information given in Level 1.
- It was very difficult with the limited information provided in Level 1 for farm planning to be able to demonstrate sustainability. This was reflected in the Level 1 scoring only 4/15 of the criteria required for an internationally recognised standard (ISO 14001).
- Level 1 enabled the farmers to do a quick and non-intimidating evaluation for their farm and give them a taste of the LEP toolkit and the confidence to move to the next level. However, the results from this research indicate that the Level 1 (1a and 1b) evaluations are sufficiently lacking detail in terms of addressing the three key drivers for advancing SNM in hill country and steepland farm systems.

**Level 2**

- Level 2 of the toolkit produces a farm plan that has more detail in terms of land resources (soils and land management units) and details about land use activities, than the introductory levels. However, there were no specifications as to nutrient discharges or any indication as to whether these discharges would have an impact on the environment or be compliant with the Councils regulations. These pieces of information were alluded to, but were not able to be extracted from the Level 2 evaluation.
- There was an improvement in the Level 2 farm plan through the addition of minimal outside input to start to identify production opportunities (versatile land classes), as well as particular environmental challenges present now or in the future (erosion and critical source areas (CSA) for P loss). However, there was a lack of linking between nutrient management issues and the various landscape units where SNM issues were more likely to occur.
- Level 2 was an improvement on Level 1; however, it was again very difficult because of the detail of information provided in the Level 2 farm plan to demonstrate sustainability. This was reflected in the Level 2 scoring 9/15 of the criteria required for an internationally recognised standard (ISO 14001).
- Level 2 is largely farmer driven (similar to Level 1), and hence, is less intimidating to the farmer, and builds upon their knowledge giving them confidence to move further on to the higher levels. The results from this research indicated that Level 2 is more useful than Level 1. However, to get the most out of the Level 2 evaluation, greater input from land management experts is required.

**Level 3**

- Level 3 of the LEP toolkit produced the most comprehensive farm plan that provided all the nutrient related information necessary, through nutrient budgets and detailed fertiliser information, to demonstrate compliance to the Regional Council. The information required was centred on land use activities around vegetation clearance (highly erodible land), nutrient discharges (N leaching limits in sensitive catchments), and cultivation (building tracks, fodder crops, riparian zones etc.).
- The Level 3 evaluation as expected, was a highly detailed and comprehensive analysis of the farm's resources, and proved the most useful in advancing SNM through the use of nutrient budgets. Level 3 provided the most utility for addressing all the SNM issues of concern for nutrient use efficiency with detailed information about nutrient inputs and losses (mainly N and P). It quantified nutrient losses to determine a trend of nutrient loss for the whole farm as well as for each of the nine nutrient management blocks, along with the various strengths and weaknesses for each LUC class on the farm that help the farmer utilise their land to its optimal potential.
- Level 3 was a major step up from Levels 1 and 2; however, Level 3 requires expert input (LUC mapping, Nutrient budgets etc.). An audit framework was set out but does not have an enforced third party audit of the farm plan as part of the process. This is a crucial part of the LEP toolkit that needs to be changed to be able to meet international environmental standards (ISO 14001 standard).
- Level 3 in contrast to the other levels was completed with a large input from the outside (land management experts, fertiliser representatives etc.) and these took time and resources to complete. With such a great outside input, there is the risk that the farmer can get intimidated and overwhelmed with the amount of information and not use the WFP at all. On the other hand, in addition to the comprehensive information gathered, the Level 3 evaluation also provided the greatest opportunity to interact with the farmer on a one-to-one basis. This provided the openings during the case study to enlighten the farmers (case farm and workshops) on particular issues (P loss from CSA). However, for the more engaged farmers, or farmers that have major SNM issues present on their farm, the Level 3 evaluation might not be comprehensive enough to achieve further growth or deal with the issues at hand.

**Recommendations**

- Investigate the possibility of combining Level 1 (1a and 1b) with Level 2 as a single exercise. Within the same workshop, Level 1 would be used as an introductory step to the completion of the level 2 plan.
- Greater integration of the Level 3 with other farm planning tools has the potential to extract greater value from the information collected and analysis as part of the process in developing a Level 3 plan but also the opportunity to better integrate resource management into the business planning cycle. Linking to other farm planning tools e.g. nutrient budgets and nutrient management

plans, FARMAX, market orientated QAP's and whole farm business plans (life cycle assessment) would be the first step in enabling the elements of the Level 3 plans to be incorporated into more of the features (e.g. business and market requirements) of the farming business. An integrated farm planning tool would increase the utility of the toolkit by allowing the SNM issues to be considered alongside all the other drivers influencing the business.

- To improve the understanding of farmers and the industry of linkages between the landscape and nutrient cycles, through the introduction of the idea of the effect of nutrient transfer within the landscape in the earlier levels (Level 1 and 2), and undergo an investigation using more accurate soil mapping techniques, soil tests and conceptual models in an investigation at Level 3.
- The use of enhanced soil mapping techniques of areas that are particularly vulnerable or identified as versatile (production opportunities) would also enable exploration of these potential issues and/or opportunities to be more in depth.

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# Chapter Seven Appendices

**Appendix 1: Whole Farm Plan Springvale Station** (LandVision Ltd, 2012)